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INSTITUTIONS

O F

MEDICINE.

P A R T I.

P H Y S I O L O G Y.

For the use of the STUDENTS, in the University
of EDINBURGH.

By WILLIAM CULLEN, M.D.
PROFESSOR OF THE PRACTICE OF PHYSIC, &c.

THE FOURTH EDITION, CORRECTED.

LIBRARY.

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ADVERTISEMENT.

THE following sheets were originally printed as a text-book for the use of Students of Medicine in the University of Edinburgh; it of course contains only sketches of what was more fully delivered in the Professor's lectures. Though the impression formerly made has been long ago disposed of, the Author did not choose to renew it till he should be at leisure to give it to the public in a more complete form. But Dr. Gregory, who now teaches this branch of medicine, thinking those sketches might be useful to his Students, the author has consented to the republication: and it is now offered to the public in a more correct manner.

THESE

THESE



I N S T I T U T I O N S

O F

M E D I C I N E.

I.

MEDICINE is the art of preventing and of curing diseases.

II.

Before considering the application of this art to particular diseases, certain general doctrines are necessary to be premised, which are called THE INSTITUTIONS OF MEDICINE.

III.

The Institutions of Medicine are divided into three parts.

The

The first treats of life and health.

The second delivers the general doctrine of diseases.

The third delivers the general doctrine concerning the means of preventing and curing diseases.

P A R T

P H Y S I O L O G Y.

IV.

THE doctrine which explains the conditions of the body and of the mind necessary to life and health, is called **P H Y S I O L O G Y**, or the Doctrine of the Animal Oeconomy.

V.

The functions of the animal œconomy are many and various ; and so complicated with each other, that it is difficult to find the most proper order in which they may be delivered. That, however, seems the best which considers them as nearly as may be according to the series of causes and effects.

VI.

Upon this plan we shall treat,

1. Of the solid matter, of which a great part of every organ of the body consists.

2. Of the nervous system, in which the motions of the body for the most part begin, and upon which the motions produced in it chiefly depend.

3. Of the motion and circulation of the blood, and of the several organs and actions employed in supporting it.

4. Of the functions employed in supporting and repairing the several solid and fluid matters of the body ;

body ; and, on this occasion, of the nature of the several fluids themselves.

5. Of the organs employed in receiving and modifying the impressions of external bodies necessary to sensation; and of their several functions.

6. Of the motions of the whole body, or of its several parts which depend on the action of muscles, and not before explained.

7. Of the functions peculiar to the sexes, and of generation.

P H Y S I O L O G Y.

S E C T. I.

OF THE SIMPLE SOLIDS.

VII.

THE solid parts of the body seem to be of two kinds ; one whose properties are the same in the dead as in the living, and the same in the inanimate as in many inanimate bodies ; the other, whose properties appear only in living bodies. In the last, a peculiar organization, or addition, is supposed to take place; in opposition to which, the first are called the SIMPLE SOLIDS. Of these only we shall treat here ; and of the others, which may be called VITAL SOLIDS, being the fundamental part of the nervous system, we shall treat under that title in the following section.

VIII.

VIII.

The simple solids are suited to the purposes of the animal œconomy by a certain force of cohesion, joined with a certain degree of flexibility and elasticity.

IX

These properties of the simple solids, in different parts of the body, in different bodies, and on different occasions in the same body, are necessarily in different degrees ; and this seems to depend upon the difference of the mixture, aggregation, or organization of the solid.

X.

The matter of the simple solid every where, except in the bones, appears to be an homogeneous aggregate ; and there is no proper evidence of its being formed of certain parts naturally discrete and incoherent, which are cemented by others of a different nature.

XI.

Of the simple solid considered as an homogeneous aggregate, the integrant parts are a mixt. which seems to be nearly of the same kind in all the different parts of the human body, and perhaps in most of the parts of every animal : So far as we yet know, the variety of it is very inconsiderable.

XII.

This, which may be called the ANIMAL MIXT,
B is

is found, by chemical experiment, to be considerably different from every kind of vegetable or fossil matter ; but the same experiments hardly teach us any thing exact or useful with respect to the constituent parts of this mixt.

XIII.

The only particular relative to this, which we exactly know, is, that the animal mixt is formed of water, and of some other matter concreting with it ; that, on different occasions, the state of it is varied by the proportion which the water bears to the other concreting matter ; and that, especially by a different proportion in this respect, the simple solid differs in its force of cohesion, flexibility, and elasticity (VIII.)

XIV.

The proportion of water to the other matter in the animal mixt of different persons seems to depend, in the first place, upon the nature of the original stamina in each ; as the different state of the simple solids, which appears early to distinguish sex and temperament continues respectively the same through the whole of life, even though the different persons are under the same external circumstances.

XV.

But, in every particular person, that proportion is constantly changed by the progress of life ; and this happens more or less as other causes concur.

XVI.

XVI.

The causes that can affect the mixture of the simple solid, are either the state of the nutritious fluid conveyed by the ordinary channels, or some matters from without insinuated into the solid.

XVII.

The state of the nutritious fluid may be varied by the quantity and quality of the aliment taken in, by the powers of concoction and assimilation, by the circumstances of application and concretion, or by certain preternatural matters carried along with it.

XVIII.

The external matter that may be insinuated into the simple solid is various, but for the most part is only aqueous moisture in greater or less quantity.

XIX.

That these several causes may affect the proportion of water in the simple solid, and thereby give a different state of it, is sufficiently obvious: That the same causes may also affect the other concretizing matter, we can, in general, perceive to be possible; but in what manner, or upon what occasions they do so, is not easily discerned.

XX.

The properties of the simple solid (VIII.) may be also varied by its state of aggregation; and this again may be varied, 1. By the temperature of the atmosphere to which the body is long exposed.

2. By

2. By the pressure, external or internal, which is applied to the solid. 3. By the degree of extension of the solid beyond its natural state, which, in every living body, is given more or less to every part of the soft or flexible solids ; and, *lastly*, by the motion or rest to which the solid is accustomed.

XXI.

The properties (VIII.) of the solid parts are also varied by the state of their organization. This every where depends upon an arrangement of fibres, the state of cellular texture, or upon a texture of vessels ; and therefore, to explain the different states of organization, it will be enough to mention the causes of the differences which occur in these fundamental parts.

XXII.

Fibres may differ in size by the several causes (XIV.—XXI.) affecting the mixture and aggregation of the matter of which they are formed, and by these causes alone ; but how far the organization of any part depends upon an arrangement of fibres, we cannot distinctly perceive ; and, if it does, we cannot perceive that the state of such parts differs otherwise than by the state of the cellular texture every where interposed between the supposed fibres.

XXIII.

The state of cellular texture is the most important circumstance in all organized parts ; and it may be varied by many different causes. 1. The texture

texture may be more dense, and thereby firmer, as it has been more pressed by the actions of life or external force; by which means especially it is changed in the progress of life. 2. The cellular texture may be increased in bulk, and rendered firmer by a new growth taking place in it, as frequently happens in membranes which are slowly and gradually stretched out. 3. The same texture may become weaker by some part of it being eroded by acrid matters generated in the body, or externally applied. 4. It is analogous to this, that when any part is sustained by several layers of cellular texture or membranes, such support is weakened by one or more of these layers being cut through; and the same weakness is induced when any external compression, which for some time, had been applied, is taken away. 5. The state of the cellular texture is varied by the matter contained in its cells; which is sometimes a matter concreting into a solid mass, and sometimes a preternatural quantity of an aqueous inelastic fluid. The bones formed in the first manner may again become soft by the hardened matter's being dissolved & reabsorbed. 6. When the mobility of parts on one another depends upon the extent of cellular texture connecting them, that mobility is diminished or destroyed by a great part of the cellular texture being eroded or cut away, and the remaining parts being united together; so that the parts are now connected by a shorter portion of cellular texture than before. 7. Parts naturally separate may lose their mobility by being joined together
by

by a cellular texture formed between them, as happens when any two surfaces are for some time kept closely applied to each other.

XXIV.

In so far as a solid part is formed by a texture of vessels, its properties (VIII.) may be varied by the different states of these vessels ; which 1. may be more or less full of fluids. 2. They may be changed into a solid mass, by the fluid, contained and stagnating in them, concreting into a solid. 3. They may be changed into a solid, if the fluids that should pass through them are intercepted, and the cavity is filled with a cellular texture ; or, 4. They may be changed into a solid, if, by collapse or pressure, the sides of the vessels are applied to each other and concrete together.

XXV.

The pathology of the simple solids cannot be properly separated from their physiology ; and therefore many different states of these solids, though such as are always morbid are mentioned above. We think it proper to subjoin here a short view of the whole of that pathology,

XXVI.

The diseases of the simple solids are,

I. Those of the naturally soft parts.

1. Debility with flexibility.

Debile tenerum, gracile, Gaub Pathol.

161 1

Debile

Debile tabidum Gaub. *ibid.* 161. 2.

2. Debility with fragility.

Debile fissile Gaub. 161. 3.

3. Laxity.

Debile laxum, flacidum, Gaub. 160. 1.

4. Flaccidity.

Debile iners Gaub. 160. 2.

5. Rigidity diminishing flexibility.

Rigidum tenax Gaub. 165. 1.

6. Rigidity destroying flexibility.

Rigidum durum Gaub. 165. 2.

II. Those of the naturally hard parts.

1. Flexibility.

Debile flexile Gaub. 160. 3.

2. Fragility.

Fragile spongiosum Gaub. 161. 4.

Fragile vitreum Gaub. 165. 3.

Of all these morbid affections, we suppose the remote and proximate causes may be understood from what is delivered above (XIV.—XXIV.)

S E C T. II.

OF THE NERVOUS SYSTEM.

XXVII.

The nervous system, as the organ of sense and motion, is connected with so many functions of the animal œconomy, that the study of it must be of the utmost importance, and a fundamental part of the study of the whole œconomy.

A general

A general view of the Nervous system.

XXVIII.

The nervous system consists of the medullary substance of the brain, cerebellum, medulla oblongata, and spinalis ; and of the same substance continued into the nerves, by which it is distributed to many different parts of the body.

XXIX.

The whole of this system seems to be properly distinguished into these four parts.

1. The medullary substance contained in the cranium and vertebral cavity ; the whole of which seems to consist of distinct fibres, but without the several fibres being separated from each other by evident enveloping membranes.

N. When we speak of functions, which are or may be in common to every part of this portion of the nervous system, we shall speak of the whole under the title of the **BRAIN** ; but, when it is necessary to distinguish the particular parts, we shall take care to avoid ambiguity.

2. Connected with one part or other of **N 1** : are, the **NERVES**, in which the same medullary substance is continued but here more evidently divided into fibres, each of which is separated from the others by an enveloping membrane derived from the pia mater.

3. Parts of the extremities of certain nerves (2.), in which the medullary substance is divested of the enveloping membranes from the pia mater and so situated as to be exposed to the action of
certain

certain external bodies, and perhaps so framed as to be affected by the action of certain bodies only: These we name the **SENTIENT EXTREMITIES** of the nerves,

4. Certain extremities of the nerves (2.) so framed as to be capable of a peculiar contractility: and, in consequence of their situation and attachments, to be, by their contraction, capable of moving most of the solid and fluid parts of the body. These we name the **MOVING EXTREMITIES** of the nerves: They are commonly named **MOVING** or **MUSCULAR FIBRES**,

N. That the muscular fibres are a continuation of the medullary substance of the brain and nerves, has not been shown by the anatomists, nor universally admitted by the physiologists; but we now suppose it, and hope afterwards to render it, sufficiently probable,

Are the ganglions of the nerves to be considered as a part of the nervous system distinguished by a peculiar function?

XXX.

These several parts of the nervous system are every where the same continuous medullary substance which we suppose to be the vital solid of animals, so constituted in living animals, and in living systems only, as to admit of motions being readily propagated from any one part to every other part of the nervous system, so long as the continuity and natural living state of the medullary substance remains.

N. It

N. It is observed, that the compression of any part of the medullary substance prevents the communication of motion between the parts that lie on different sides of the part compressed ; and it is probable, there are other causes besides compression, which may also affect the medullary substance, so as to interrupt in it the communication of motion ; but they are not distinctly known. In the mean time, we use the expression, that a nerve, or other proportion of the nervous system, is *free*, to denote its being free, not only from compression, but from every other supposed cause interrupting the communication of motion.

The condition fitting the medullary substance for having motion propagated in it, we suppose to be the presence of a certain fluid ; which we therefore name the *nervous fluid* without meaning however at present to determine any thing with regard to its source, nature, or manner of acting.

XXXI.

In the living man, there is an immaterial thinking substance, or MIND, constantly present ; and every phenomenon of thinking is to be considered as an affection or faculty of the mind alone. But this immaterial and thinking part of man is so connected with the material and corporeal part of him, and particularly with the nervous system, that motions excited in this give occasion to thought ; and thought however occasioned, gives occasion to new motions in the nervous system. This mutual communication or influence we assume with confidence as a fact : But the mode of it we do not understand, nor pretend to explain ; and therefore are not bound to obviate the difficulties that attend any of the suppositions which have been made concerning it.

XXXII.

The phenomena of the nervous system occur
commonly

commonly in the following order. The impulse of external bodies acts upon the sentient extremities of the nerves ; and this gives occasion to preception or thought, which, as first arising in the mind, we term SENSATION. This sensation, according to its various modification, gives occasion to VOLITION, or the willing of certain ends to be obtained by the motion of certain parts of the body ; and this volition gives occasion to the contraction of muscular fibres, by which the motion of the part required is produced.

N. This is an example of the most ordinary case ; but we do not mean to say it is the only case of communication between the different parts of the nervous system.

XXXIII.

As the impulse of bodies on the sentient extremities of a nerve does not occasion any sensation, unless the nerve between the sentient extremity and the brain be free (XXIX. 3.) ; and as in like manner, volition does not produce any contraction of muscles, unless the nerve between the brain and muscle be also free ; we conclude, from both these facts, that sensation and volition, so far as they are connected with corporeal motions, are functions of the brain alone ; and we presume, that sensation arises only in consequence of external impulse producing motion in the sentient extremities of the nerves, and of that motion's being thence propagated along the nerves to the brain ; and in like manner, that the will operating in the brain only, by a motion begun there, and propagated along the

the nerves, produces the contraction of muscles.

XXXIV.

From what is now said, we perceive more distinctly the different functions of the several parts of the nervous system, as distinguished in (XXIX.)

1. The sentient extremities (XXIX. 3.) seem to be particularly fitted to receive the impressions of external bodies ; and, according to the difference of these impressions, and of the condition of the sentient extremity itself, to propagate along the nerves motions of a determined kind, which, communicated to the brain, give occasion to sensation.
2. The brain (XXIX. 1.) seems to be a part fitted for, and susceptible of, those motions with which sensation, and the whole consequent operations of thought are connected ; and thereby is fitted to form a communication between the motions excited in the sentient, and those in consequence arising in the moving extremities of the nerves, which are often remote and distant from each other.
3. The moving extremities (XXIX. 4.) are so framed as to be capable of contraction, and of having this contraction excited by motion propagated from the brain, and communicated to the contractile fibre.
4. The nerves, more strictly so called (XXIX. 2.) are to be considered as a collection of medullary fibres, each enveloped in its proper membrane, and thereby so separated from every other, as hardly to admit of any communication of motion from any one to the others, and to admit only of motion along the continuous medullary

medullary

lary substance of the same fibre, from its origin to the extremities, or contrariwise.

XXXV.

From this view of the parts of the nervous system, of their several functions and communication with each other, it appears, that the beginning of motion in the animal œconomy is generally connected with sensation ; and that the ultimate effects of such motion are chiefly actions depending immediately upon the contraction of moving fibres, between which and the sentient extremities the communication is by means of the brain. Wherefore, in studying the nervous system, we judge it proper to consider, 1. Sensation, and with that the general function of the sentient extremities. 2. The action of the moving fibres. 3. The function of the brain. In considering these three heads, the function of the nerves, more strictly so called, will of course be sufficiently explained.

C H A P. I.

O F S E N S A T I O N.

XXXVI.

O U R sensations may be considered as of two kinds ; 1. Those which arise from the impulse or impression of external bodies, which we therefore name SENSATIONS OF IMPRESSION. 2. Those which arise from the mind's being conscious of its own action, and of the motions it excites ;

excites ; and these we name SENSATIONS OF CONSCIOUSNESS.

Sensations of Impression.

XXXVII.

The sensations of impression are very various ; but have been generally referred to five heads or kinds, commonly called the five senses ; that is, those of sight, hearing, smell, taste, and touch.

XXXVIII.

The four first of these are each of them properly considered, as forming one genus of sensations : 1. As the particular sensations comprehended under each head (XXXVIII), though very various, are, however, perceived to have somewhat common to all of them. 2. As those of the same genus all arise from impressions made upon one part of the body only, and that of a peculiar organization. 3. As those of the same genus all arise from the action of external bodies of one kind only, or of one and the same quality, by means of which they act upon our organs.

XXXIX.

No such characters concur in establishing one genus of the sensations referred to the fifth head of touch, which are various in all those respects (XXXVIII.) ; and physiologists seems to have referred to this head of touch every sensation that does not manifestly belong to the other four, and among the rest many of the sensations of consciousness.

ousness. It might perhaps be useful to distinguish into genera, the several sensations referred to touch ; but it is not necessary to be done here.

From certain sensations referred to touch, it appears, that not only the extremities (XXIX. 3) but that every part of the nervous system (XXVIII.), is sentient with respect to certain impressions.

Sensations of Consciousness

XL.

The sensations of consciousness may be referred to the following heads : 1. Those of apperception, by which we are in general conscious of thinking of perceiving, judging, and willing, and thereby of our existence and identity. 2. The sensations arising from the particular state of thinking, as perception, memory, and judgment, are more or less clear, ready, or exact. 3. The sensations arising from the particular state of volition, and its various modes. 4. The sensations arising from the general state of action, as vigorous or weak, easy or difficult. 5. The sensations arising from particular actions, or a consciousness of the actions excited, and of the motion of the different parts of the body. 6. The sensations arising from the diminution or absence of impressions.

Under each of these heads, a great number of particular sensations are comprehended, but not necessary to be farther specified here.

Laws

Laws or general Circumstances of Sensation.

XLI.

Of the four first genera (XXXVII.), the sensations arising give no indication of the nature of the bodies acting on our organs, or of the mode of their action ; and when we otherwise learn these circumstances, we can perceive no necessary connection between them and the sensations which they produce. But, from certain sensations of touch and consciousness, we acquire the notions of solid figure, of motion, impulse, impenetrability, and the communication of motion, and consider the sensations as exactly correspondent to the circumstances of external bodies. At the same time, as we know of no other action of bodies on each other but that of impulse ; and as, in the case of the sensations of the four first genera, we learn, that an impulse takes place, we have comprehended the whole under the title of Sensations of impression, and consider all of them as perceptions of impulse.

XLII.

To produce any sensation of impression, a certain force of impression is necessary ; and from a lesser force, no sensation arises. The degree of force is likewise so limited on the other hand, that, in a high degree, it destroys the organ ; and, in degrees approaching to this, a general sensation of pain, rather than the sensation of any particular object, is produced.

XLIII.

XLIII.

Within these limits, however, our sensations are not exactly correspondent to the force of impression, nor do they make any exact estimate of that force. Usually sensation is relative to the change that is produced in the nervous system ; and a sensation proves strong or weak, only as it is stronger or weaker than that which had immediately preceded it, or than that degree of force to which the nerves had been immediately before accustomed. For this reason too the limits (XLII,) are very variable.

XLIV.

Different sensations do not always imply a different kind of action in the bodies producing them ; for sometimes different sensations arise merely from a different degree of force in the same kind of action, as is manifest in the case of heat and cold.

XLV.

To sensation from impression, a certain duration of impression is necessary.

XLVI.

The mind's resting for some time upon one sensation, is called ATTENTION. This, like duration (XLV.), is necessary to give an impression its full effect.

XLVII.

The mind seems to be determined to attention by the force of impression ; by the pleasure or pain arising from it ; by the degree of emotion or passion

sion produced by these ; and, lastly, by the emotion's being more or less related to the person feeling.

XLVIII.

If the force and duration of impression, and the attention of mind, are all in the due degree, the sensation often remains for some time after the impression or action of the external body has ceased.

XLIX.

The mind admits of, or can attend to, one sensation only at one time.

L.

Though the mind admits but of one sensation at one time, several impressions may act at the same time, if they be such as can unite in producing a single sensation ; and such is the case of many of the impressions which produce the particular sensations of the same genus, as in those especially of colour, sound, smell, and taste.

LI.

In each of these genera, many impressions, which separately produce particular species, can unite in producing a single sensation, which is always a neutral, or one different from either of the separate sensations.

LII.

This union of impressions may take place, either when the impressions are exactly synchronous, or when the one succeeds the other before the sensation of the first (XLVIII.) has ceased.

LIII.

LIII.

Though the motion excited in the sentient extremities by impression remains some time, as in (XLVIII.), it must be supposed to become continually weaker, till at length it ceases altogether, and with it the sensation.

LIV.

The same impression soon repeated, does not produce the same strength of sensation as before. Hence, all new impressions are *cæteris paribus*, strongest : and moderate impressions frequently repeated, produce no sensation, unless their force is considerably increased.

LV.

Actions which at first produced a sensation of consciousness, as accompanied with volition, come, by repetition, to be performed without any sensation ; or they produce it only when they are performed with uneasiness, pain, or unusual force.

LVI.

Impressions being given, their effects in producing sensations are different in different persons, and in the same person at different times. This must arise from some difference in the state of the bodies acted upon, which may perhaps be referred to the following heads : 1. The state of the common teguments, or other parts interposed between the impressing body and the medullary substance of the sentient extremity. 2. The different state of the medullary substance of the sentient extremities, as given to it in the original stamina: 3. The

3. The different state of tension in the medullary substance of the sentient extremities, as given to it by the state of the blood-vessels constantly connected with it. 4. The state of the same medullary substance, as affected by heat or cold. 5. The state of it as produced by former impressions (XLIII. LIV.) 6. The state of the nerves along which the motion is propagated. 7. The state of the brain or sensorium. 8. The state of attention (XLVI. and XLVII.)

LVII.

Different parts of the body are sensible, and sensible only by means of nerves present in them: but anatomy does not always determine certainly with regard to the presence or absence of nerves ; and, therefore, the sensibility of several parts can be determined by experiment only ; which, however, is also fallacious.

LVIII.

Particular sensations arise from impressions on certain parts only : 1. Because the sentient extremities in these parts are so situated as to be exposed to the action of certain external bodies only. 2. Because the sentient extremities are connected with an organ that increases the force of the external agent, or modifies its action in the manner necessary to a determined impression. 3. Because the fibres of certain sentient extremities are, by their size or tension, fitted to be acted upon by certain external bodies only. 4. Because certain sentient extremities are so constantly preserved in

a certain state, as to render them more sensible to a change.

These circumstances determine the mode of impulse, but do not account for the sensation arising from it.

LIX.

Different sensations are accompanied with different judgments concerning the bodies making impression, and the part of the human body upon which it is made. Some sensations are referred to bodies at a distance ; others, to external bodies in contact ; and others to the feeling body itself.

LX.

When sensations are referred to our own bodies, it is in three several ways ; They are most commonly referred to the part on which immediately the impression is made ; and this, with regard to the external parts, very accurately ; but, with regard to the internal, much less so : And commonly the sensations arising from internal parts, are referred to the incumbent external part, with some obscure distinction between superficial and more deep. 2. Sensations are sometimes referred, not to the part upon which the impression is immediately made ; but to a distant more sensible part to which a motion is propagated from the part impressed. 3. As sensations usually arise from impressions made upon the extremities of the nerves, and are referred to these ; so impressions made on the nerves in their course, are sometimes referred to the extremities from whence they had commonly arisen.

LXI.

The sensations of consciousness (XL. 1.2.) are referred to the *encephalon*. So are those of XL. 3. if they are moderate; but, if more vehement, they are often referred to those parts in which their effects are exerted, as the heart and organs of respiration. The sensations (XL. 4 and 5.) are seldom, with accuracy, referred to particular parts, but indistinctly to a whole number. We are not conscious of the action of particular muscles, except when their contraction is spasmodic.

LXII.

We are disposed to combine our sensations as united in one object; and thus form what are called COMPLEX IDEAS.

LXIII.

We compare our several sensations, and from thence acquire new sensations of RELATION.

LXIV.

When sensations formerly received are again renewed by the same objects, it is, for the most part, with a consciousness of their having been formerly received; and this faculty we call REMINISCENCE.

LXV.

Perceptions formerly received can be renewed without the presence or action of the object which formerly gave occasion to them: and if this is attended with the consciousness of a difference between the vividness of the two perceptions, and particularly

ticularly of the absence of the original objects, such a renewed perception is called an **IDEA**; and the faculty by which this renewal is made, is called **MEMORY**.

LXVI.

Perceptions formerly received; can, without the presence of the original object; be renewed also in such a manner, that the mind does not perceive any difference between the original and the renewed perception; and therefore, such renewal is always attended with the persuasion of the presence of the object. The faculty by which such renewal is made, we call **IMAGINATION**, more strictly.

LXVII.

Reminiscence depends upon the force or frequent repetition of the former sensation.

LXVIII.

Memory depends upon an association of perceptions, which is formed by their being frequently repeated immediately after each other; by their being parts of the same complex idea; and, by their having relations marked. Memory is generally faithful to such associations: but it is more or less so in different persons, according to the number and importance of the relations marked; according to the frequency of the repetition of the sensations and the marking of their relations; and according to the different states of the brain, very little known.

LXIX.

Imagination seems always to depend upon internal causes, that is, upon causes acting in the brain.

LXX.

LXX.

Memory and imagination renew distinctly the ideas of seeing and hearing only. All others are renewed imperfectly, or not at all ; but all others may be associated (LXVIII.) with the sensations or ideas of seeing and hearing, so that these become signs of the others. The memory, in renewing these signs, so far renews the idea belonging to them, as to renew their several associations and relations ; to renew, in some degree, the pleasure or pain which formerly attended the sensations themselves : and particularly to renew the emotions of mind, or motions of the body, which the sensations formerly produced.

LXXI.

Most of our sensations, perhaps all of them, are either pleasant or painful.

LXXII.

The words *pleasant* and *painful* are commonly generic terms, each of them comprehending a great many species, which seem to require being assorted under several different genera. Thus, in the first place, our sensations may be divided into those we desire, and those we are averse to. Of those we desire we may distinguish those which arise from qualities we refer to other bodies, from those we refer entirely to our own. The first may be named more strictly the AGREEABLE, the last the PLEASANT. In like manner, of the sensations we are averse to, we may distinguish the DISAGREEABLE and the PAINFUL. But, farther, the last must be distinguished from the sense of aversion, which

which accompanies certain sensations of consciousness, as the sense of debility, lassitude, difficulty, &c. and particularly from that which is referred obscurely to internal parts, and this we name ANXIETY. These sensations may be called the UNEASY; and every one distinguishes this kind from that of the PAINFUL, more strictly so called. These last seem to be always sensations of impression, referred pretty accurately to a particular part.

There is thus a foundation for establishing different genera of the sensations we desire, and of those we are averse to; as also, for greater precision in the employment of terms: but the fixing the limits of these genera, and assorting the several species, may be still difficult; so that we cannot be certain of applying the terms every where with strict propriety.

LXXIII.

The enumeration of the agreeable or disagreeable, and even of the pleasant sensations, would not be of much use here; and the enumeration of the uneasy and painful, though much more interesting, belongs to the pathology. However, we think it proper to deliver here the few following propositions.

LXXIV.

Sensation and action, within certain limits, are always desired; and the want of sensation, or imperfect and indistinct sensations, are always uneasy. In action of every kind, the sensations of debility and difficulty are also uneasy.

LXXV.

LXXV.

In sensations of impression, their being pleasant or painful often depends on the degree of force in the impression, allowance being made for the sensibility of the system.

LXXVI.

As impressions, by being repeated, produce weak sensations (LIV.), impressions, at first painful, may, by repetition, be changed into pleasant, and the pleasant into insipid and uneasy. Hence arises, with regard to moderate impressions, the pleasure of novelty, the desire of variety, and the desire of increasing the force of pleasant impressions.

LXXVII.

There is a condition of impressions, rendering them objects of desire or aversion, that cannot with certainty be referred to their force. This condition we call the quality of impressions.

LXXVIII.

Impressions are often rendered objects of desire or aversion, by combination, succession, and relation.

LXXIX.

No sensations arise originally in the mind, without a previous change in the state of the body.

LXXX.

Certain impressions, and certain states of the body, like to those which produce the sensations of consciousness, may both of them act upon the nervous system, without producing any sensation.

S E C T. II.

C H A P II.

O F T H E A C T I O N O F M O V I N G F I B R E S.

LXXXI.

THE moving fibres (*XXIX* 4.), so far as yet known, are of one kind only, and the same every where, as in the most commonly known muscles. Hence, the terms moving and muscular fibres are of the same import.

LXXXII.

A muscular fibre is supposed to have a peculiar organization, different both from that of the simple solid fibre, and from that of the medullary fibres in every other part of the nervous system; but wherein that peculiarity of organization consists, is not yet ascertained.

LXXXIII.

A muscular fibre is endued with a contractility, which is different from that of the simple solids, or of any inanimate elastics, especially in this, that the contraction of a muscular fibre is excited by causes which do not affect these others. For, the contraction of a muscular fibre is excited by being extended; and a contraction is produced, whilst the stretching power continues to be applied. The same contraction is also excited by various applications, whose mode of action we do not perceive; but we know them to be such as do not affect inanimate elastics.

In respect of these causes by which it may be excited, the contractility of muscular fibres hath been called IRRITABILITY.

LXXXIV.

The force of contraction in muscular fibres is often much greater than that of the causes exciting it.

LXXXV.

The contractility of muscular fibres (LXXXIII.) appears especially in living bodies, ceases with life, or soon after, and is probably never produced but with life. Hence it is, that by some writers, it is called the VITAL POWER; and the muscular fibre endued with it, the LIVING SOLID. *Gaub. Patholog.* 169, 170.

LXXXVI.

The contractility (LXXXIII. LXXXIV. and LXXXV.) hath been supposed to belong to muscular fibres, independently of their connection with the other parts of the nervous system; and upon that supposition, it hath been called the *vis insita*. We shall call it the INHERENT POWER; *Haller. Prim. lin.* 400.

LXXXVII.

The contraction of muscular fibres can be excited by applications made to other parts of the nervous system, as well as to the muscles; and, as the effects of those applications made to the other parts of the nervous system can be prevented by ligatures made upon the nerves between the place of application and the muscle to be moved, it is concluded that the contraction of muscular fibres can be excited

cited by a power communicated to them by a motion propagated along the nerves. This power is called the **NERVOUS POWER**.

LXXXVIII.

The nervous power (*LXXXVII.*) is commonly determined to motion by the will. This we suppose to act in the brain only (*XXXIII.*), and to depend upon sensation, and other modifications of thought ; and this power, which is to be chiefly referred to the mind, and acts in the brain only, we name the **ANIMAL POWER**.

LXXXIX.

The facility with which the contraction of muscular fibres can be excited, and the force with which it can be performed, are to be distinguished. The first we name the **MOBILITY**, the last the **VIGOUR**, of muscular fibres. Both have been confounded under the name of Irritability.

XC.

The mobility and vigour of muscular fibres (*LXXXIX.*) can both of them be increased or diminished by various means. Whatever can excite the contraction of muscular fibres is called **STIMULUS** ; and, in general the means of exciting contraction are called **STIMULANT POWERS**. The means diminishing the mobility and vigour of muscular fibres are called **SEDATIVE POWERS**.

XCI.

The inherent power (*LXXXVI.*) is supposed to be more vigorous, moveable and permanent, in certain muscular fibres than in others.

XCII.

XCII.

The inherent power, or the contraction dependent upon it, can be excited by certain applications made either to the muscles themselves, or to the nerves connected with them; and in either case, the effects of such application are so exactly the same as to allow us to conclude, that the matter in the nerves, and in the muscular fibres, is of the same kind.

XCIII.

The muscular fibres are sensible to various impressions, and are otherwise organs of the sensations of consciousness (XL. 4. 5.) From this also, it is presumed, that the muscular fibres consist of the same matter which is the subject of sense in other parts of the nervous system (XXXIX.)

XCIV.

From XCII. XCIII. and other considerations, we think it probable, that the muscular fibres are a continuation of the medullary substance of the brain and nerves, as alleged XXIX.

XCV.

Though the muscular fibres consist of the same kind of matter as that in the nerves, the latter show no contractility, because they have not the peculiar organization (LXXXII.) of the former.

XCVI.

The nervous power (LXXXVII), and the inherent LXXXVI.), may subsist for some time without any connection of the nerves or muscles with the brain; and they subsist also in entire bodies for some time after life has seemingly ceased. Both

powers,

powers, however, are seemingly of equal duration in these respects ; and neither power seems to subsist long but in entire and living bodies.

XCVII.

From what is said (xcii.-xcvi.) it is probable, that the nervous and the inherent powers are somewhat of the same nature ; and it is also probable, that, in entire and living bodies, both the nervous and inherent powers have a constant dependence upon the animal (Lxxxviii.)

XCVIII.

The contraction of muscular fibres does not depend immediately on the motion of the blood, as it subsists in many animals after all motion of the blood has ceased.

XCIX.

The contraction of the muscular fibres does not depend on the inflation of vesicles, or other such analagous structure, as the shortening of the fibres in contraction is often greater than take place in such structure.

C.

As the force of cohesion in the muscular fibres of living animals is much greater than in those of dead ones, it is probable from this and other considerations, that the cause of muscular contraction is an increase only of that same power which gives the contractility of the simple solids, and of other inanimate elastics ; *Haller. Prim. Lin.* 407. 408.

If this is true, it will also explain why the
force

force of cohesion in muscular fibres is greater than that of the medullary fibres in any other part of the nervous system, though both kinds of fibres (byXCIV.) consist of the same kind of matter.

CI.

In living and healthy animals, the muscular fibres have a constant tendency to contract; and this tendency we call their TONE, or TONIC POWER.

CII.

The tonic power of muscular fibres necessarily supposes their being constantly in a state of extension beyond their natural or most contracted state; and in this state they are constantly kept by the action of antagonist muscles, by the weight of the parts they sustain, by fluids distending the cavities they surround, and by their connection with such distended cavities, particularly the blood-vessels.

CIII.

As the distention of muscular fibres (by LXXXIII.) proves a stimulus (xc.), we conclude, that the tonic power in them will *cæteris paribus* be in proportion to the degree of tension (CII.)

CIV.

If the inherent power (as in xcvi.) is in dependence upon the nervous and animal powers, and these may be increased or diminished by various means, the tonic, as a part of the inherent power, must in some measure be in proportion to the state of the nerves and animal powers.

CV.

CV.

If the tonic power of any muscular fibre depends more upon its state of tension (CIII.) than upon the state of the nervous and animal powers (CIV.), such fibres will be more affected by changes in the state of tension, than by changes in the state of the nervous and animal powers ; and on the contrary, &c.

CVI.

The force of contraction, or the vigour of muscular fibres, will be always as the force of stimulus, and the vigour of the animal, nervous, and inherent powers taken together.

CVII.

The mobility of muscular fibres (LXXXIX.) seems often to be increased by causes which weaken their vigour ; and, therefore, it is induced by the diminution of tension, and by causes weakening the animal, nervous, or inherent powers.

CVIII.

The ordinary contraction of muscular fibres is disposed spontaneously to alternate with a relaxation or extension of the same.

CIX.

In the straight muscles and in the heart, the alternate contractions and relaxations readily take place ; and that though a stimulus is constantly applied : but in muscular fibres surrounding cavities, as in the alimentary canal, bladder of urine, &c. the alternate motions do not appear, unless a porti-

on of the fibres is cut out, and separated from the rest.

CX.

From a difference in the state of a muscle contracted by inherent power, while the member it sustains is moved by external force, and that of the same muscle contracted by the power of the will, we perceive that in the muscles there may be a state of relaxation without their extension.

CXI.

There is a state of the contraction of muscles that is not disposed spontaneously to alternate with relaxation, and in which too the fibres do not easily yield to extending powers applied; Such a state of contraction is called a SPASM.

CXII.

When muscles are excited to contraction by preternatural causes, and are contracted with unusual velocity and force, and especially when the contractions, alternating with relaxation, are frequently and preternaturally repeated; such motions are called CONVULSIONS.

CXIII

If the contraction of muscles are exerted with unusual force, and such contractions are often repeated, they in a short time become uneasy and weaker; and though contractions are not exerted with unusual force, if they are often repeated, and for a long time, without an interval of rest, they also become uneasy and weaker.

CXIV.

CXIV.

Within certain bounds, with respect to force, frequency, and duration, the contraction of muscles, by being repeated, is performed with more facility and force.

CXV.

Are not the contractions of muscles produced by the action of the animal power; those which are more especially liable to become uneasy and weak by frequent repetition?

S E C T H.

C H A P III.

OF THE FUNCTIONS OF THE BRAIN.

CXVI.

FROM the effects of ligatures made upon the nerves, and of the destruction of their continuity, it appears, that, in their entire state, motions may be communicated from the brain to the other parts of the nervous system, and from the latter to the former; and, from the same experiments it appears, that the brain (XXIX. 1) is the organ of sensation and volition, and of the several intellectual operations intervening between these; All which is confirmed by the effects of the organic affections of the brain upon the intellectual faculties.

CXVII.

The brain is thus the sensorium or corporeal organ,

organ, more immediately connected with the mind; and, so far as corporeal organ is employed, all the operations of thought arising in consequence of sensation are operations of the brain, and are modified by its various conditions; *Boerb. Inst. Med.* 581. *Haller., Prim., Lin.* 570. *Gaub. Path., Med.* 523. See afterwards (CXXII.)

CXVIII.

As certain impressions act on the nervous system, without producing any sensation (LXXX.) and as, at the same time, there is hardly any communication between the different parts of the nervous system, but by the intervention of the brain; it is from hence also probable, that the brain, by its organization, is fitted to propagate the motions arising in one part, to the other parts of the nervous system; and, as these mechanical communications produce different effects, according to the different state of the brain itself, we, upon the whole, conclude, that the brain is a corporeal organ susceptible of various conditions, and thereby of considerable influence in most of the phenomena of the nervous system.

CXIX.

The action of the brain, in moving the several parts of the body, is excited by various causes, or by the same causes in different circumstances.

1. It is especially excited by the WILL, directing the motion of certain parts as means to an end.

As the motion of certain parts is adapted to various purposes, we are conscious of willing these purposes,

poses, as they occasionally occur, and so far also of the motion of the parts concerned in them ; but where the motion of the parts is connected with one sensation, or a few only, the motions required follow these sensations without our being conscious of specially willing them ; and, unless we have continued the practice of adapting the motions to different purposes, we lose the power of doing so, and the motions become unavoidably connected with those sensations which, for a long time, had alone given occasion to them. In most of the instances of what are called VOLUNTARY MOTIONS, we are conscious of willing the end proposed, more than the motions excited ; and of the motions produced, we are conscious chiefly of those of a whole member, or of the general effect, and very little of the many particular motions that concur to produce it. We are never conscious of the particular muscles employed.

2. The action of the brain is excited by the more general and vehement volitions named EMOTIONS and PASSIONS. Upon occasion of these, the consciousness of willing the particular motions produced is always much less distinct, and in many cases is not at all perceived. Of the last kind are, particularly, most of the expressions of the passions in the countenance and gesture.

3. By the disposition of human nature to IMITATION. This imitation is sometimes involuntary, often without consciousness ; and the consciousness which takes place is often of the general purpose only, without that of the particular motions

ons produced ; or, at least, it is of these only as a general effect.

4. By APPETITES or desires, directed to certain external objects, and arising from sensation, without any reasoning directing to an end ; at least, without any other end in the first instance but that of the gratification of the desire.

5. By certain PROPENSITIES or desires to remove an uneasy or painful sensation, in consequence of which motions are excited, which are not directed to any external object, but confined to the body itself.

These motions are not foreseen ; nor are we ever conscious of willing any thing, but the general effect. Of this kind, the chief are the motions of sneezing, coughing, sighing, hiccuping, vomiting, voiding urine and feces, yawning, stretching (*pandiculatio*) and those motions of restlessness and inquietude which pain and uneasiness produce. Weeping and laughing are expressions of emotion and passion.

In all these, as well as in the motions of N 4. some volition is concerned, not only as they can often be prevented by another volition presenting itself ; but, besides, as the several motions which occur in executing these propensities are more or fewer, and more or less forcible, according to the vehemence of the propensity or effort. Very often the stimulus to these propensities is irresistible ; and, unless the peculiar stimulus is present, the motions cannot be produced by any volition.

6. By certain internal impressions arising from the

the exercise of the functions of the body itself, which produce no sensation, nor produce motions of which we are conscious, except when exercised in an unusual manner. Such are the causes of the motions of the heart and arteries, of the organs of respiration, of the stomach, intestines, and perhaps of many other parts. With regard to most of these motions, it may be supposed, that they are the mechanical effects of their several causes, acting upon the inherent power of muscular fibres (LXXXVI.): but it is sufficiently certain, that they also depend upon an action of the brain; and the effects of passions as well as the effects of destroying or compressing the nerves of the organs concerned, are proofs of it.

The motions mentioned in this article are commonly supposed not to be accompanied with any volition of which we are distinctly conscious. This perhaps is not strictly true with regard to most of them; and, so far as it is, it may be imputed to that repetition which destroys consciousness (LV.): But neither can we entirely adopt this explanation; as these motions, which are intended to follow one stimulus only, may be supposed to require no exercise of volition, as in the case of the heart, arteries, and alimentary canal, while the action of respiration, as adapted to various purposes, continues to be a voluntary motion.

7. By various occasional impressions of external bodies, and by various occasional states of the system, or of its particular parts which excite motions, not only in the parts to which the impressions

are

are immediately applied, but also in distant parts, on which they can operate only by the intervention of the brain. Some of these causes operate with, others without, sensation or volition.

CXX.

In all, or any of these cases in which the action of the brain takes place, we do not perceive the manner, that is the mechanical means, by which the several causes produce their effects ; and we perceive only an institution of our maker, establishing a connection between the several causes and the motions which ensue. At the same time we, for the most part, perceive, that the connections established are suited to the purpose of the animal œconomy ; and particularly, to the purpose of supporting the system in a certain condition for a certain time, and of averting what might hurt or destroy it. This constitution of the animal œconomy we call NATURE ; and every where in the œconomy we perceive the *vires conservatrices* and *medicatrices naturæ*, so justly celebrated in the schools of physic.

CXXI.

It is in consequence of this constitution that not only impulse, and other causes which may be supposed to produce motion, do accordingly excite motions in the animal œconomy ; but that also many causes which seem to diminish motion, do however, produce an increase of motion in animal bodies. Thus several passions which, in the first tendency, diminish motion, several propensities arising from debility and difficulty of action, the absence
of

of usual impressions, evacuations, and other causes of relaxation, cold and narcotic powers, are all of them causes of considerable motions arising in the animal system.

CXXII.

As the mechanism of the brain, suited to its several functions, is not at all perceived (CXX.) ; and at the same time, as very few of these functions are carried on without sensation and volition, it must appear from this, and many other considerations, that the mechanism of the brain (CXVII.) would not be sufficient for the purpose, without being united with a sentient principle, or mind, that is constantly present in the living system. But, at the same time, it is with little probability alleged, that the administration of the corporeal functions is entirely directed by the mind acting independently of the body, and with intelligence perceiving the tendency of impressions, and exciting such motions as may favour the beneficial, or obviate the hurtful tendency of all causes acting upon the body.

We are certainly conscious of no such administration. Many impressions have their effects without sensation or volition. In most cases where volition takes place, it is very general, with little consciousness of the motions excited, and none at all of the organs employed. The force of impression is every where absolute ; and it is according to the force of impression, and other mechanical conditions of the system, that the motions excited prove either salutary or pernicious. The general principle,

ple, therefore, is ill-founded ; it is not necessary, (*vide Stahl. Præf. ad Junker. Consp. Med.*) ; it can be of no use, and may be hurtful to the system of physic.

CXXIII.

The action of the brain is often determined and regulated by custom and habit ; that is, by laws established by frequent and uniform repetition. See above XLIII. LIV. LV. LVI. 5. LX. 3 LXVIII. and LXX. for the effects of custom on sensation, and CXIV. for one effect of it on the action of moving fibres. It is now to be observed further, 1. That custom determines the degree of tension (CII.-CIII.) necessary to the action of muscular fibres. 2. That custom associates motions with sensations, which are not otherwise their causes ; so that the renewal of the sensation, or of its idea, renews also the motion. 3. That custom associates different motions, so that they cannot be separately performed, tho' not originally, nor necessarily connected. 4. That custom determines the degree of force and velocity with which motions can be performed. 5. That custom determines the order of succession in associated motions, and the velocity with which they shall succeed one another. 6. That custom establishes the periodical return of certain sensations and motions, not originally necessary to the œconomy. 7. That custom fixes an exact period for the return of certain sensations and motions, which by the laws of the œconomy, are disposed to return at intervals otherwise undetermined. These laws, which may be established by custom, are, many of them,

them, with difficulty avoided ; they are often rigidly fixed, have a considerable influence on the action of the brain, and govern the revolutions of the animal system. Thus, any causes producing a deviation from the usual degree of force and velocity (N. 4.) are apt to destroy the measure of it altogether ; and, in like manner, causes producing a deviation from the usual order and velocity in the succession of motions (N. 5.) are apt to destroy the power of the mind in following that order, or in giving any measure to the several motions which should be performed ; and perhaps, in this way, the effects of debility, of several passions and of surprise, are in some measure explained.

CXXIV.

The brain seems, by its constitution, to be disposed to the alternate states of rest and activity ; as appears in the alternate states of sleep and waking, which constantly take place in every animal ; but wherein this constitution consists, it is difficult to discover.

CXXV.

The most common opinion is, that the brain is a secretory organ, which secretes a fluid necessary to the functions of the nervous system ; that this fluid is alternately exhausted and recruited, and and thereby gives occasion to the alternate states of sleep and waking. But this supposition is attended with many difficulties. 1. It is probable, that the nervous fluid existed in the animal embryo, before the action of the heart, or any secretory function, could take place. 2. In animals
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which during the winter suffer a temporary death, such as bats, when by heat they are again restored to life, the vital power of the solids is restored before the fluidity of the blood. 3. The nervous fluid subsists in the nerves and muscular fibres long after they are separated from the brain, and often when cut into many small parts. 4. Though it be true that the brain is a secretory organ, the fluid secreted may be destined to another purpose; and so far as we understand that purpose, the fluid fit for it, must be unfit for the purpose of sense and motion. 5. There is no appearance, in any part of the nervous system, of provision made for an occasional accumulation of the secreted fluid; nor is there any evidence of its actually taking place. 6. The phenomena of sleep and waking do not correspond with such a supposition; as sleep often takes place when the secreted fluid must be copiously present, and waking can be protracted when the fluid is exhausted much beyond its usual measure. 7. Both states are induced by many causes, which can hardly be supposed to act upon secretion.

CXXVI.

A certain compression of the brain can produce a state of the system resembling sleep; but that state is in some respects, different from that of ordinary sleep; And it does not by any means appear that natural and ordinary sleep depends upon any compression of the brain.

CXXVII.

As it is therefore propable that sleep and waking do not depend upon a different quantity of the
matter

matter of the nervous fluid for the time present in the system (CXXV.), or upon any causes interrupting its motion, while the condition of the matter remains the same (CXXVI.); we are disposed to believe, that those states of sleep and waking depend upon the nature of the nervous fluid itself capable of becoming more or less moveable ; that it is chiefly in the brain susceptible of these different conditions ; and that, especially by its condition there, it has its more general effects on the whole system.

CXXVIII.

This may perhaps be confirmed by considering the remote causes of sleep and waking : And it appears, that cold, the absence of impressions, attention to a single sensation, or to sensations that have no consequence in thought or action ; the finished gratification of all vehement desires, sedative sensations and impressions, evacuations, relaxation, and any violent, frequent, or long continued exercise of the animal power ; are all of them, severally or together, causes inducing sleep.

CXXIX.

On the other hand, it appears, that a certain degree of heat, all sensations of impression, impressions analogous to those which produce sensation, all sensations which lead to thought and action, and the increased impetus of the blood in the vessels of the brain, are all of them causes favouring or inducing a state of waking.

CXXX.

CXXX.

As most of the causes CXXVIII. are evidently such as diminish motion in the brain and those of CXXIX are such as increase it ; it is from thence probable, that the nervous fluid in the brain is truly capable of different states or degrees of mobility, which we shall call its states of EXCITEMENT and COLLAPSE ; but, without intending, by these terms, to express or determine any thing with regard to the nature of the nervous fluid, or wherein its different states consist.

CXXXI.

This subject may be further illustrated by, observing, that the excitement of the brain appears to be in very different degrees on different occasions. It seems to be greatest in certain maniacs endued with uncommon strength, resisting the force of most impressions. and with the utmost difficulty admitting sleep.

CXXXII.

A lesser degree of excitement occurs in the ordinary state of waking men in health, when the excitement is total with respect to the functions of the brain, but readily admitting of sleep. This excitement may be considered as of two kinds ; either as it respects the vigour or as it respects the mobility of the system. And these different states of the brain are expressed in the body, by strength or debility, alacrity or sluggishness ; and in the mind, by courage or timidity, gaiety or sadness.

CXXXIII.

A degree of collapse takes place in the case of
natural

natural sleep, when the collapse prevails so far as to suspend very intirely the exercise of the animal functions ; and, though the exercise of the vital and natural continue, they are considerably weakened. The partial collapse that may take place in the brain discovers itself by the delirium which appears in a state that often occurs as intermediate between sleep and waking ; and even in sleep the collapse with respect to the animal functions, takes place more or less entirely ; whence the sleep is with or without dreaming, and the dreaming is more or less active.

CXXXIV.

A still greater degree of collapse takes place in the case of syncope ; in which it is so great, as to suspend the exercise of the vital functions concerned in the circulation of the blood, notwithstanding the force of habit in these, and their being exposed to constant stimuli. Here the collapse may be very considerable ; but there still remains some degree of excitement while the brain can be acted upon by stimuli, which act only on vital powers, and while its usual excitement is still recoverable by such stimuli.

CXXXV.

If the collapse is still more complete and irrecoverable, it is the state of DEATH.

CXXXVI.

From what is now said of the excitement and collapse of the brain, it will appear, that we suppose LIFE, so far as it is corporeal, to consist in
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the excitement of the nervous system, and especially of the brain, which unites the different parts, and forms them into a whole. But, as certain other functions of the body are necessary to the support of this excitement, we thence learn, that the causes of death may be of two kinds ; one that acts directly on the nervous system, destroying its excitement ; and another that indirectly produces the same effect, by destroying the organs and functions necessary to its support. Of the first kind are chiefly the causes of sleep operating in a higher degree ; as cold, sedative passions, poisons, and all causes of very violent excitement.

CXXXVII.

This subject may receive still further illustration from considering the state of other parts of the nervous system with respect to excitement and collapse. In the nerves strictly so called (xxix. 2.), we do not know that the nervous fluid suffers any change, but what is exactly correspondent to its state in the brain and extremities ; and therefore the only difference of the state of the nerves to be taken notice of is their being more or less free (xxx).

CXXXVIII.

In the sentient extremities of the nerves (XXIX. 3.), a difference of the state of the nervous fluid arises from the several causes mentioned (LVI. 2. 3. 4. and 5.), which give a different degree of sensibility ; and it is probable, that these different states of the sentient extremities are analogous to the different degrees of excitement in the brain.

CXXXIX.

CXXXIX,

The moving extremities, or muscular fibres(x. XIX. 4.), may also be in a different condition with respect to excitement. It is probable, that their constitution is such as to admit of a higher degree of excitement than any other portion of the nervous system; and that upon this their contractility depends. But, whatever is in this, we perceive very clearly, that the condition of muscular fibres may be varied by causes affecting their tonic power (CI.), or their vigour and mobility (LXXXIX.), and by the effect of custom (CXIV.); and it is probable, that the states produced by these causes are analogous to the different degrees of excitement in the brain (CXXX.) and in the sentient extremities (CXXXVIII.); and thus the several parts of the nervous system (XXIX.), as they consist of the same kind of matter (XCIV.), are also subject to similar conditions,

CXL.

The beginning of motion in the nervous system is most commonly accompanied with sensation, and the force of this in producing its several effects is more or less. 1. According to the force (XLII.) quality (LXXVII.), and novelty (LIV.) of impression. 2. According to the sensibility of the sentient extremity and brain (LVI.) 3. According to the state of attention (XLVII.) These several causes often concur, frequently balance one another, and are always to be considered together.

CLXI.

The effect of sensation is commonly that of ex-
H
citing

citing the action of the brain ; and this is generally according to the degree of volition produced under the different circumstances mentioned in CXIX.

CXII.

The action of the brain excited by volition or other causes, is determined to particular parts of the body, most constantly by the connections established in the system (CXX.), but also occasionally, by acquired habits, or the greater mobility of certain parts.

CXLIII.

With regard to the connections established in the system (CXX. CXXI.) it is to be observed, as of great consequence in pathology, that certain parts of the body which have a common function and constitution, have thereby a peculiar relation to the brain, so as to be more liable to be affected by the different states of it. and in their turn by the difference of their condition to affect the brain. Such are, especially, the organs of voluntary motion ; the alimentary canal, and especially the stomach ; the circulatory system and particularly the extremities of the vessels on the surface of the body ; the uterine and genital system in females ; and some others to be mentioned in the pathology.

CXLIV.

The communications of motion between the several parts of the nervous system which have been mentioned as instances of a particular sympathy between these parts, are very seldom to be explained

ed by any contiguity or contact, either in the origin or course of the nerves of the communicating parts ; and more commonly they may be explained, by supposing the action of the impression to be general with respect to the brain, and that the affection of particular parts depends upon the causes of determination (CXLII. CXLIII.)

When the action of several parts, together or successively, are necessary to produce one effect, these concur, though the stimulus exciting the action of the brain is applied to one single part only ; and commonly no other cause of communication can be assigned, but the several motions being necessary to the execution of the volition, propensity, &c, arising from the stimulus.

CXLV.

These are the chief facts and laws relative to the nervous system. The whole might perhaps be illustrated, and more exactly ascertained, by a more particular inquiry into the nature of the nervous fluid ; but we are not so confident in our opinion on this subject, or of the application it will admit of, as to deliver it here.

S E C T, III.

OF THE CIRCULATION OF THE BLOOD.

CXLVI.

THE circulation of the blood, by CXXIX. seems necessary to the excitement of the brain ; and for this, as well as other reasons, it is,

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next after the function of the brain itself, the most important of the animal œconomy.

On this subject, we shall consider, 1. The course of the blood. 2, The powers by which the blood is moved. 3. The laws and general circumstances of the circulation. 4. Respiration as necessary to it.

On all these subjects we suppose the anatomy of the parts to be known:

S E C T. III.

C H A P I.

OF THE COURSE OF THE BLOOD.

CXLVII.

WOUNDS and hemorrhagies show that, in living bodies, the blood is in constant motion, and flowing into any one part from many others.

CXLVIII.

In man, and other analogous animals, which have once breathed for some time, the course of the blood is very constantly in the following manner.

From the left ventricle of the heart, the blood passes into the trunk of the aorta and successively into the following vessels and cavities, viz. the branches of the aorta, the branches of the vena cava, the trunk of the same, the right auricle of the heart, the right ventricle of the same; the pulmonary

pulmonary artery, the pulmonary veins, the left auricle of the heart ; from which last it passes into the left ventricle of the heart to return again into the same course as before.

From all this, it appears, that in the arteries the usual course of the blood is from the heart towards the extreme branches of these ; and that, in the veins, the course is in the contrary direction, from the extreme branches towards the heart.

CXLIX.

The course of the blood through the cavities of the heart, as above described, is not in a continued stream but alternately interrupted and free during the contraction and dilatation of those cavities, which alternately happen. Thus, while the left ventricle of the heart is in a state of contraction, the blood passes out of it into the aorta ; but at the same time no blood passes into it from the left auricle, which is then dilated and filled by the blood flowing into it from the pulmonary vein. It is only when the ventricle is emptied by contraction, and consequently relaxed, that the blood passes into it from the auricle, urged by the contractions of the auricle and adjoining sinus venosus, which succeed immediately to that of the ventricle. During this contraction of the auricle and filling of the ventricle, no blood passes from the ventricle into the aorta ; nor till a contraction of the ventricle succeeds in consequence of its being filled. The same circumstances take place with regard to the right ventricle and auricle of the heart, and precisely at the same times ; for it appears,
that

that the two ventricles of the heart are contracted and relaxed at the same time ; and, in like manner, the two auricles.

CL.

That the course of the blood, as described CXLVIII. and CXLIX. is its usual and constant course, appears from inspection of the heart in living animals ; from the situation of the valves of the heart ; from the situation of the valves at the orifices of the aorta and pulmonary artery ; from the situation of the valves of the veins ; from the effects of ligatures made upon the arteries and veins ; from the effects of hæmorrhagies of the veins ; from observations with the microscope ; and, lastly, from experiments of infusion and transfusion in living, and of injection in dead animals.

CLI.

This course of the blood is, however, in some parts, and upon some occasions, a little changed.

1. In the penis, and some other parts, the blood does not pass from the extreme arteries immediately into continuous veins ; but is poured out into an intermediate cellular texture, from which it is afterwards received by the extreme veins. 2 In the small branches of the aorta, the blood does not move constantly in a direction from the heart towards the extremities ; but in certain portions of them, is sometimes retrograde to that course. In this, it is favoured by the anastomoses frequent between the small vessels, which at the same time, prevent this deviation from being considerable or durable, while the action of the heart continues.

CLII.

CLII.

In the course of the venous blood, there is also some variety. 1. In the small veins, the blood is liable to have a motion retrograde to its usual direction. (CXLVIII.), as in the arteries (CLI. 2.) 2. The blood, returning to the heart from most parts of the body, passes successively from smaller into larger veins, by a series of pretty regularly increasing vessels, till they form the vena cava entering the heart. But this is varied in the abdomen, where the veins carrying the blood returning from every viscus included in that cavity, except the kidneys and genitals, unite in forming the vena portarum, whereby they undergo a peculiar distribution. 3. The veins returning the blood from the extreme arteries in the brain, do not carry it to the heart by a series of regularly increasing vessels, but by the interposition of sinuses, into which the small veins issuing from the cortical part of the brain immediately pour their blood. 4. As the course of the blood through the vessels of the lungs is not at all times equally free, and particularly is considerably interrupted at the end of expiration; so at the same time it is also interrupted at entering the right ventricle of the heart; and this often occasions some regurgitation, or retrograde motion, in both the ascending and descending cava.

CLIII.

The whole of the fluids carried in the aorta to its extreme branches, are not returned again by the continuous veins to the heart, as by secretory vessels,

vessels, a part of them is constantly carried out of the course above described. Some of these secreted fluids are thrown entirely out of the body, and others are poured into certain cavities, for various purposes of the œconomy ; and some of these are again returned into the course of the circulation. Of these last, there is a peculiar fluid which from the extremities of the arteries, is poured out in a liquid form, or exhaled in that of vapour, into perhaps every cavity and vacuity of the body. This, after having served the purpose of the effusion, seems intended to be regularly returned again into the course of the circulation ; and accordingly, in all the several cavities into which it had been effused, there are absorbents which again take it in. These do not carry the fluid immediately into the veins ; but uniting, form the vessels called LYMPHATICS, which, in their course, pass through the conglobate glands, and at length terminate either in the receptacle of the chyle, in the thoracic duct, or in the left subclavian vein and, in this way, return the absorbed fluid into the course of the ordinary circulation.

CLIV.

There are absorbent vessels, not only in all the several cavities, but also on the external surface of the body, by which many extraneous matters may be introduced into it.

CLV.

Most of the fluids secreted from the circulating mass, and poured into cavities, may be absorbed from these, and returned again by the lymphatics

as in CLIII. to the course of the circulation. But the same secreted fluids seem often to be returned also into the course of the circulation by a regurgitation, or retrograde motion, in the excretory and secretory vessels.

S E C T. III.

C H A P II.

O F T H E P O W E R S M O V I N G T H E B L O O D.

CLVI.

THE chief power by which the blood is moved, and the circulation carried on, is the action of the heart, or its repeated contractions occurring, as mentioned CXLIX. For this purpose the heart is a muscular part ; the action of which may depend upon an inherent power stimulated by the dilatation of its cavities ; but this inherent power requires the constant support of the nervous and animal powers, and is often actuated by these.

CLVII.

The contraction and relaxation of the heart, or, as these are called, its systole and diastole, are necessarily alternate by the general law (CVIII.) affecting all muscles, and by the stimulus from the influx of venous blood being alternately applied and removed.

CLVIII.

If we may be allowed to estimate the vigour of

I

muscles

muscles by the number of their fibres, we must suppose the force of the heart to be very considerable ; but it is very difficult to obtain any exact estimate of its absolute force. It is perhaps the relative force only that we are concerned to know.

CLIX.

Do the arteries, by their contraction, contribute to promote the motion of the blood begun by the heart ? They cannot do it by the elasticity of the simple solid in their structure ; and can do it only by their being endued with a muscular power, whereby they may, in their contraction, communicate to the moving blood more than was lost of the force of the heart in dilating them. That they are indued with a muscular contractility (LXXXI-I.), is probable from the appearance of the muscular fibres in their structure ; from their irritability appearing in the experiments of *Vershuir* ; from their becoming flaccid on tying the nerves belonging to them ; from the motion of the blood being supported, when the force of the heart is considerably weakened ; from the motion of the blood becoming languid, when the action of the arteries is destroyed ; from the velocity of the blood in the extreme arteries being greater than was to be expected from the velocity of the blood issuing out of the heart, exposed to so many causes of retardation as constantly occur ; and, lastly, from the velocity and impetus of the blood in different parts of the body, and at different times, being unequal, while the action of the heart continues the same.

It is probable, that the muscular fibres of the arteries

teries become more irritable as the arteries are more distant from the heart.

CLX.

The tone and action of the arteries, as a muscular part, may be increased by stimuli immediately applied to them, or by the increased force of the nervous and animal powers with regard to them; and they may be diminished by sedative powers applied, or by weakening the nervous and animal powers.

CLXI.

There does not appear to be any oscillatory motion in the extreme arteries independent of the action of the heart.

CLXII.

There does not appear to be any operation of capillary attraction in the extreme arteries; nor does there seem to be any occasion for such a power in any part of the arterial system.

CLXIII.

The power of derivation (*Vis derivationis Ill. Halleri* 174.) in the sanguiferous system, seems to be no other than that which arises from the fulness of contractile vessels.

CLXIV.

The motion of the blood in the arteries of any particular part is promoted by the action of adjoining muscles.

CLXV.

The blood in the vena cava, and its branches,

is moved by the action of the heart and of the arteries. These powers are assisted by the action of muscles, which, in their contraction, press the veins lying between their several fibres; and also, by the swelling of their whole mass, press the adjoining veins. These veins are commonly provided with valves, which determine the effect of all pressure upon them, to be the motion of the blood towards the heart.

The great trunks, both of the vena cava and pulmonary vein, are provided with muscular fibres, and manifestly endued with muscular contractility.

CLXVI.

In the absorbent vessels, the fluids are probably taken in by a capillary attraction.

CLXVII.

In the lymphatic vessels, provided with numerous valves, which necessarily determine the motion of the contained fluid to be towards the heart; the fluid is moved by the pressure of the neighbouring muscles and arteries. But further, as the lymphatics are remarkably irritable, it is probable that the fluid in them is moved by a peristaltic motion begun by the action of their absorbent extremities.

CLXVIII.

The motion of the blood through the vessels of the lungs, depends upon respiration, to be considered hereafter.

S E C T. III.

C H A P. III.

OF THE LAWS OF THE CIRCULATION.

CLXIX.

THE velocity of the blood passing out of the left ventricle of the heart into the aorta, may be estimated from knowing the quantity of blood passing out at each systole, the area of the orifice of the aorta, and the time occupied by the systole ; but none of these circumstances are exactly ascertained.

CLXX.

As the blood moves onwards through the arteries, the velocity (CLXIX.) suffers a considerable retardation from several causes. 1. From the capacity of the arteries being enlarged as they are more distant from the heart. 2. From the frequent flexures of the arteries. 3. From the angles which the branches make with the trunks from which they arise. 4. From anastomoses. 5. From the viscosity of the blood. 6. From the friction of adhesion. 7 From the weight and rigidity of the parts surrounding the arteries.

CLXXI.

The velocity (CLXIX.) and the causes of retardation (CLXX.) being given, the velocity of the blood in the arteries will be as the frequency of the systole of the heart.

CLXXII.

CLXXII.

The frequency of the systole of the heart will be more or less, 1. As the blood in the veins is more or less quickly returned to either ventricle of the heart. 2. As the ventricles of the heart are more or less entirely evacuated at each systole. 3. As the muscular fibres of the heart are more or less moveable. 4. As the action of the nervous and animal powers are more or less increased with respect to the heart.

CLXXIII.

As the arteries of a healthy body are always full, the blood thrown out of the ventricles into the arteries during the systole of the heart, can only find a place there by pushing on the blood with the velocity (CLXIX.), or by dilating the arteries; but as the resistances CLXX. prevent the blood from flowing with the velocity CLXIX. the blood thrown out of the heart must, in some measure, dilate the arteries, and thereby form what is called the PULSE.

CLXXIV,

It appears, that, in the arteries to a certain length, the blood moves faster during the systole than during the diastole of the heart; but as the resistances and causes of retardation become greater in every portion of the arteries as it is more distant from the heart, so the acceleration of the blood during the systole of the heart must be greater in any portion of the arteries nearer the heart than in the next adjoining that is more distant

tant; and so far as this takes place, a dilatation of the arteries will happen, even from a small quantity of blood thrown out of the ventricles.

CLXXV.

As the resistances to the blood's motion in the blood-vessels increase with the distance from the heart, there may be a part of the sanguiferous system in which the motion of the blood will not be accelerated during the systole of the heart, and in which, therefore, no pulse can be discerned. This happens in the extreme branches of the aorta; and no pulse is ever observed in the extreme branches of the vena cava.

CLXXVI.

The velocity and impetus of the blood in the whole system of blood-vessels will always be as the action of the heart and arteries taken together.

CLXXVII.

The velocity and impetus of the blood, in any particular part of the system, will be, 1. As the part is more or less distant from the heart. 2. As the circumstances (CLXX.) take place more or less in the part. 3 As the gravity of the blood concurs with, or opposes its motion in the part. 4. As causes increasing or diminishing the action of the arteries of the part are applied or removed.

CLXXVIII.

The quantity of blood distributed to any particular part of the sanguiferous system, will be greater or less according to the velocity and impetus of the blood in the part, by CLXXVII. ; and according

according to the resistances in other parts being increased or diminished by constriction, compression, ligature, position, relaxation, or aperture.

CLXXIX.

The flexibility and contractility of the blood-vessels render the effects of all increase or diminution of resistance in any particular part most considerable in the nearest, and very little so in the more remote, vessels of the system. By this we are to judge of the celebrated doctrines of derivation and revulsion.

CLXXX.

The quantity of blood distributed to the different parts of the system, is in different proportion at different periods of life.

1. The capacity and force of the heart, in proportion to the system of vessels, is greater at the beginning of life than at any after period. Till the body arrives at its full growth, the capacity of the vessels increases in greater proportion than that of the heart ; but from that period, the capacity of the vessels is constantly diminishing, while that of the heart suffers little change.

2. A greater quantity of blood is contained in the arteries, in proportion to that which is contained in the veins, at the beginning of life, than at any after period. From the time that the body has arrived at its full growth, the quantity of blood contained in the veins, in proportion to that which is contained in the arteries, is constantly increasing.

3. The

3. The vessels of the head receive a greater quantity of blood, in proportion to the rest of the system, at the beginning of life than at any after period.

4. Any general increase of the action of the heart and arteries determines the blood more copiously to the extreme arteries on the surface of the body, than to those of the internal parts.

5. The equilibrium of the sanguiferous system, with regard to the distribution of the blood, may be changed by various causes (CLXXVII. CLXXVIII.) ; and these causes continuing to operate for some time, induce a habit which renders the changed distribution necessary to the health of the system.

6. The lymphatic system is fuller in young persons than in old.

S E C T. III.

C H A P IV.

O F R E S P I R A T I O N.

CLXXXI.

RESPIRATION consists of the motion of inspiration, or the admission of air into the lungs ; and of expiration, or the expulsion of air from the same ; alternately happening.

CLXXXII.

Respiration takes place in man, and other analogous

logous animals, soon after the infant is taken from the uterus of the mother, and is exposed to the air. After it has taken place for a little time, it is ever after necessary to the continuance of life, as it is absolutely necessary to the continuance of the circulation of the blood.

CLXXXIII.

The lungs are a hollow spongy mass, capable of confining air, and readily dilatable by it. By the wind-pipe, they are open to the atmosphere ; and they are so situated in the thorax, that the air must enter into them, if the cavities of the thorax, in which they are placed, are enlarged. For, as there is no air in these cavities, and the external air cannot enter into them, the enlargement of the thorax must form a vacuum around the lungs which the external heavy and elastic air will supply by entering into and dilating the lungs, while these do not allow the air to pass through them into the cavities of the thorax.

CLXXXIV.

Inspiration therefore depends upon the enlargement of the capacity of the thorax ; and this is performed chiefly by the contraction of the diaphragm. This in its relaxed state is suspended by the mediastinum, and its middle tendinous part is raised high in the thorax ; wherefore, as this middle part, by the contraction of the muscular, is moved downwards, the thorax is thereby considerably enlarged.

CLXXXV,

The capacity of the thorax is also enlarged by the motion

motion of the ribs upwards whereby the curvatures of opposite ribs are set at a greater distance from each other ; and, by the same motion, the sternum is moved outwards, and set at a greater distance from the vertebræ of the back. The motion of the ribs upwards is caused by the contraction of both layers of intercostal muscles. That the muscles called internal intercostals concur with the external in raising the ribs, appears from the situation of those muscles, from the greater mobility of the inferior ribs, from the inspection of those muscles in living animals, and from experiments imitating their action. In more violent and laborious inspirations, the raising of the ribs is assisted by many muscles attached to the ribs, and arising from the clavicle, humerus, scapula, and vertebræ of the neck or back.

CLXXXVI.

By the enlargement of the thorax, a dilatation of the lungs is produced, in proportion to the bulk of air entering into them ; but the dilatation may often be greater by the air that enters into the lungs being heated and rarified ; and the greatest distension of the lungs is obtained by a constriction of the glottis confining the air that has already entered into the lungs.

CLXXXVII.

As inspiration, or the admission of air into the lungs, depends upon the enlargement of the thorax, the diminution of it must expel the air, or produce expiration. The capacity of the thorax is diminished, while the muscles dilating it are spontaneously

spontaneously relaxed, by the elasticity of the ligaments connecting the ribs with the vertebræ, and by the elasticity of the cartilages and ligaments connecting the ribs with the sternum ; both which powers, commonly assisted by the weight of the ribs themselves, bring the ribs and sternum into the position they were in before inspiration. At the same time, the elasticity of the mediastinum draws the diaphragm upwards ; and the contraction of the abdominal muscles both presses the diaphragm upwards and pulls the ribs downwards ; and in the last, they are assisted by the sterno-costal and infra-costal muscles. While these powers concur in diminishing the capacity of the thorax, the expulsion of the air from the lungs is assisted by the the elasticity of the lungs themselves, and by the contraction of the muscular fibres of the bronchiæ.

CLXXXVIII.

These are the ordinary powers of expiration, which, depending upon the reaction of elastic parts, is performed slowly, and with little force : but when it is necessary to perform it with more velocity and force, some other and very powerful muscles, as the quadratus lumborum, sacrolumbalis, and longissimus dorsi, concur in pulling down the ribs ; and, at the same time, the abdominal muscles, actuated by the animal power, are contracted with greater velocity and force than in spontaneous expiration.

CLXXXIX.

The situation of the blood-vessels of the lungs is such, that, in the contracted state of this viscus, these

these vessels must be much folded and straitened ; and it appears, that, in the foetus, where they are constantly in a contracted state, their capacity is not sufficient to transmit, in the time required, the whole of the blood returning to the heart by the vena cava ; but, after respiration has been repeated for some time by the dilatation of the lungs to a certain degree in inspiration, their blood-vessels are unfolded, lengthened, and enlarged, so as to be capable of transmitting the whole blood of the cava.

CXC.

In the infant who has breathed for some time, the whole blood of the vena cava passes into the right ventricle of the heart, and from thence enters into the vessels of the lungs ; but, in the contracted state of the lungs which occurs at the end of expiration, the blood cannot be properly transmitted ; and, for that purpose, an inspiration becomes absolutely necessary.

CXCI.

It is, however, under a certain degree of inspiration only, that the blood is freely transmitted through the vessels of the lungs ; for, if the inspiration is full, and continued, so that the lungs are thereby much distended, we find that this state also interrupts the free passage of the blood, and renders expiration necessary.

Expiration becomes also necessary ; because, perhaps, the air long retained in the lungs loses a part of its elasticity, and becomes thereby unfit

to keep the lungs distended; but, more certainly, and more especially; because; in an animal that has breathed for some time, there is a noxious vapour constantly arising from the lungs, which, if not dissolved by the air, and carried out of the lungs, proves pernicious to life.

CXCH.

From what has been said, it appears. that the alternate motions of inspiration and expiration are necessary to the circulation of the blood, and otherwise also to the health of the body; and it appears also, that the more frequent the alternate motions of respiration are, the more quickly is the blood transmitted from the right to the left ventricle of the heart.

CXCHII.

We can now perceive also the causes exciting these alternate motions; and we find no occasion for supposing them to arise from any causes alternately interrupting the motions of the nervous fluid, or of the blood, into the muscles concerned in these functions.

Inspiration, or the action of the muscles producing it, is excited, in all cases of general effort, to remove pain and uneasiness; and it is, perhaps a propensity of this kind that gives the first beginning to respiration in the new born infant, exposed to several new and uneasy impressions.

For the continuance of respiration, inspiration is especially excited by the sense of uneasiness that attends any difficulty in the passage of the blood
through

through the vessels of the lungs ; but this uneasiness arises, in some measure, at the end of every expiration, and is much increased by any continuance of this state.

CXCIV.

Expiration, in some measure, necessarily succeeds inspiration, by the spontaneous relaxation of the inspiratory muscles (CVIII.), while the elasticity of the membranes, ligaments, and cartilages stretched in inspiration, brings back the ribs and diaphragm into their former situations ; and the same effects are also produced by the action of the abdominal muscles, and of the muscular fibres of the bronchia ; both of which are stretched, and thereby excited in inspiration.

In the case of ordinary inspiration, these causes are sufficient to produce a spontaneous expiration. But as it appears that a violent and long continued inspiration interrupts the passage of the blood through the lungs, this creates an uneasiness, and a propensity, which must produce a relaxation of the inspiratory, and excite a contraction of the expiratory, muscles.

It is further to be supposed, that, in animals which have breathed for some time, custom has associated the several motions concerned both in inspiration and expiration ; so that an irritation applied to any part of them necessarily excites the whole ; and it may also be supposed, that habit determines these motions regularly to succeed one another.

CXCV.

CXCIV.

In this manner (CXCIII. CXCIV.) respiration is continued for the general purposes of the animal œconomy ; but the several motions of which it consists are also occasionally excited and variously modified by the will, intending particular effects to be produced by these motions. They are also excited, and variously modified, by certain emotions and passions, and give particular expressions of these. They are often excited also by imitations ; and they are particularly excited by propensities to remove pain and uneasiness, which operate more frequently on respiration than upon any other function.

CXCVI.

The consideration of the effects of respiration on the animal fluids is delayed till the nature of these fluids shall have been more generally considered.

S E C T. IV.

OF THE NATURAL FUNCTIONS

CXCVII.

THE animal body from a small beginning, grows to a considerable size ; and at the same time, from the period of the birth, during the whole of after life, the body suffers, by various means, a daily considerable waste.

CXCVIII.

The increase of bulk, therefore, must be acquired,

red, and the daily waste supplied, by matters taken into the body, the most part of which, from the presumed purpose of them, we name ALIMENTS.

CXCIX.

A great part of these aliments, as taken into the body, are of a different nature from the matter of the body itself ; or at least, are in such a state as not to be fit for being immediately applied to the purposes of it : they must, therefore, be changed, and fitted to the purposes of the œconomy, by powers within the body itself.

CC.

The conversion, or assimilation, of the aliments to the nature of the solids and fluids of the animal body ; the farther changes of these fluids for various purposes, by secretion ; and the application of some part of them in nutrition, or in increasing the growth of the body ; make what are called the NATURAL FUNCTIONS.

S E C T. IV.

C H A P. I.

O F D I G E S T I O N.

CCI.

THE term *digestion* is commonly employed to signify the function of the stomach alone in changing the aliments ; but, in this chapter, we are to consider all the changes of these as they oc-

cur successively in the different stages through which the matters pass.

CCII.

Animals are determined to take in aliment, by the appetites of hunger and thirst.

CCIII.

Hunger is an appetite depending upon a sensation referred to the stomach, and arising from a particular state of it.

This state seems to be in some respect the degree of emptiness, but more especially the state of contraction in the muscular fibres which emptiness gives occasion to. This state of contraction may also be excited by certain stimulants applied ; but more commonly it depends upon, and is correspondent to, the state of inanition, and therefore of contraction, in the vessels of the skin emitting the matter of perspiration.

CCIV.

Thirst is an appetite for liquids, which depends upon a sensation chiefly referred to the internal fauces, and arising from the dryness or heat of these parts ; from acrimony applied to them, or existing in the fluids poured out there ; from the putrescency or viscosity of the contents of the stomach ; and from all increased evacuations.

CCV.

These appetites determine men to take in a great variety of solid and liquid matters, directed by instinctive likings and disgusts ; in some instances corrected by experience.

CCVI.

CCVI.

Of the matters chosen, it appears that some of them are suited to supply the matters of the fluids or solids of the body, and therefore properly named Aliment ; while others of them are suited only to improve the relish of aliment, or to obviate some deviations ready to happen in the business of digestion ; and these we name CONDIMENTS.

CCVII.

The proper alimentary matters are animal or vegetable only.

CCVIII.

The animal aliments seem to be so nearly of the same nature with the matter of the body itself, that to be rendered fit for the purposes of the œconomy, they seem to require no other change but that of being rendered fluid.

CCIX.

But the vegetable aliment is very different from the matter of the animal fluids or solids, and must therefore be changed into the nature of these by the powers (CXCIX); and as many animals are nourished by vegetable aliment alone, and as perhaps all animal matters may be ultimately traced to a vegetable origin, it will appear, that, to account for the production of animal matters, it is especially, and in the first place, necessary to show how vegetable matter may be converted into animal.

CCX.

If we consider the many different odours, tastes,
and

and colours, which are to be observed in different vegetables, we should be ready to think that vegetable matter is of very great variety : but we know that the matter distinguished by its sensible qualities makes but a small part of the whole of any vegetable ; and that, besides the matter peculiar to each, there is in most, perhaps in all vegetables, a large proportion of common matter, which we presume to be the matter adapted, and that very universally, to the aliment of animals.

CCXI.

It is this common matter of vegetables, therefore, that we are to consider here ; and we think it may be considered as of three kinds only ; that is, oily, saccharine, and what seems to be a combination of these two.

CCXII.

The oily matter of vegetables, which makes part of the aliment of animals, is without any sensible odour or taste ; and is not only very nearly the same in the many different vegetables from which we take it, but is also in all of these so nearly a-kin to the oil which appears in animals, that it is not necessary to suppose any considerable change to be made upon the vegetable oil on its being taken into the bodies of animals.

CCXIII.

It is the saccharine matter, especially this when blended with oily matter in different proportion, that makes the greatest part of the common matter of vegetables, and is the chief part
of

of the vegetable aliment of animals. It is this, therefore, that we have especially to consider here ; and as it lies in vegetables, it is different from the most part of animal matters in the following respects .

It is readily susceptible of a vinous and acetous fermentation, and spontaneously enters into the one or the other of these ; and, without undergoing more or less of these, it perhaps never enters into a putrefactive fermentation.

The same matter treated by distillation, without addition, gives out always, in the first part of the distillation, an acid and only afterwards a volatile alkali in small proportion.

The same vegetable matter, treated by calcination, leaves ashes, which contain a fixed alkali, and an earth that is or may be converted into a quick-lime.

CCXIV.

In all these respects, the common matter of animals is considerably different.

This enters spontaneously into a putrefactive fermentation, and that without passing through the vinous or acetous : At least, these are not to be distinctly perceived.

The same animal matter, treated by distillation, gives out always, in the first part of the distillation, a volatile alkali in large proportion, and only afterwards by a great force of fire it gives out an acid.

Animal matters, treated by calcination, leave
ashes,

ashes, in which no alkali is to be found ; and the earth is not calcareous, nor convertible into a quick-lime, by any means yet known.

CCXV.

These differences are sufficiently marked ; but it is proper to observe here, that the vegetable matter we treat of, by undergoing a putrefactive fermentation, is changed so, as to acquire very exactly most of those characters of animal matter we have just now mentioned.

CCXVI.

The aliment being thus considered, we proceed to consider the changes it undergoes after being taken into the animal body ; but, first, of the course it passes through, and of the motions it is subjected to in its progress.

CCXVII.

The aliment is taken into the mouth ; and there the more solid parts of it are commonly subjected to a triture, or what is called manducation. At the same time a quantity of saliva, and of the other fluids of the mouth, with some portion of our drink, is intimately mixed with it, whereby the whole is reduced to a soft pulpy mass. In this state, by the action of deglutition, it passes through the fauces into the œsophagus, by which it is conveyed into the stomach.

CCXVIII.

Here the aliment is detained for some time, subjected to a constant agitation and some pressure, both by the contractions of the different parts of
the

the stomach itself, and by the alternate pressure of the diaphragm and abdominal muscles. After some time, however, first the more fluid parts, and at length the most minute parts of the solid matter are pushed thro' the pylorus into the duodenum.

CCXIX.

The matters received from the stomach into the duodenum pass on from thence successively through the several parts of the intestinal canal; and, in the whole of the course, the matters are still subjected to the alternate pressure of the diaphragm and abdominal muscles, and to the contractions of the intestines themselves.

CCXX.

Through the whole course of the intestines, but especially in those named *the small*, the more fluid part of the contents, and particularly the peculiar fluid we name *chyle*, is taken into the vessels named *lacteals*. These, from imperceptible beginnings on the internal surface of the intestines, unite into larger vessels laid in the mesentery, and convey the chyle, and what accompanies it, first into the conglobate glands of the mesentery, and from thence to the *receptaculum chyli*, as it is called. From this the chyle passes by the thoracic duct into the left subclavian vein. In one or other part of this course of the chyle, the vessels carrying it are joined by lymphatics, returning the lymph from almost every part of the body.

CCXXI.

The matters contained in the intestinal canal,
not

not taken into the lacteals, are moved onwards in the course of the intestines, becoming by degrees of a thicker consistence, especially in the colon, where their motion is considerably retarded ; but at length, they are moved onwards to the extremity of the rectum, where their weight, bulk and acrimony excite motions which throw them entirely out of the body.

CCXXII.

This is the course of the alimentary matters, so far as they can be considered as any ways in a separate state. Of the motions of the several organs concerned in this course, we pass over those of manducation, deglutition, or others depending on the action of the muscles, the functions of which are readily understood from a knowledge of their situation ; and we are here to consider only the motions of the alimentary canal itself.

CCXXIII.

The motions in the œsophagus depend upon the action of its muscular fibres, which are chiefly those forming a chain and circularly surrounding it. This tube, by the morsel of food pushed into it by the action of deglutition, is necessarily dilated, and its circular fibres are thereby excited to a contraction. But as these fibres are successively dilated, so are they also contracted, and push on their contents through the several portions of the tube, alternately and successively dilated and contracted, giving the appearance of a vermicular motion, and what is commonly called peristaltic. This motion may be propagated either upwards or
downwards ;

downwards ; and the direction of it is in the one or the other way, as the motion happens to begin at the upper or lower extremity.

CCXXIV.

The motion of the stomach is not so simple. Its muscular fibres are in like manner irritable by dilatation, and its circular fibres must therefore be in some measure subjected to a successive dilatation and contraction. But, though the direction of such motions is from the left to the right, this does not immediately push the contents of the stomach into the intestines. It seems to be the purpose of the œconomy, to detain the aliment for some time in the stomach ; and therefore, any considerable dilatation of the circular fibres, especially that which occurs in a full stomach, seems to have the effect of exciting the longitudinal fibres to a contraction which draws the two orifices of the stomach nearer to one another. By this the pylorus is raised up and rendered less easily passable ; and probably, at the same time, the peculiar band of circular fibres which surround the pylorus, are more firmly contracted, and render it less pervious, Vide (CXLIV.) From hence it is, that the direction of the peristaltic motion of the stomach is sometimes from the left to the right, and sometimes also the contrary way. It is however, most constantly in the first manner ; because it is commonly begun from the œsophagus, and because, when it is inverted, the resistances on the left from the blind sac of the stomach, from the higher situation of the cardia, and from the con-

striction of this by the diaphragm in inspiration, are commonly more considerable than the resistance at the pylorus. The contents of the stomach, therefore are at length pushed through the pylorus; in the first place, the more fluid contents, as these occupy the antrum pylori, while the more solid, having their air loosened by fermentation, are rendered specifically lighter, and float nearer the upper orifice. But at length, as the stomach is in any measure emptied, the pylorus is less raised, is more relaxed and allows matter to pass more easily; and at the same time, the empty stomach contracted more, is especially towards the right extremity contracted to such a degree, as to embrace the smallest solid matters, now fallen down into it, and to push them through the pylorus.

This is an idea of the ordinary motions of the stomach; but they are, upon some occasions, subject to other modifications, as in eructation, rumination, and vomiting, which, however, as morbid, we reserve to be considered in the pathology.

CCXXV.

The motions of the intestines will be readily understood, from what has been said of those of the œsophagus. Any portion of the intestinal canal being dilated, will in consequence be contracted, and will urge on its contents in the same direction in which the motion was begun. But as the force here is gentle; and as, in the long course of the canal, there occur many flexures, different positions, and occasional irritations; it is obvious, that resistances and stronger contractions may frequently

quently occur here, to change the direction of the motion : accordingly we find it frequently changed, and directed from below upwards, in so far that the contents of the intestines frequently pass into the stomach. But the motions of the intestines are, however, most constantly directed from above downwards, both because they are commonly begun from the stomach, and because, when inversions do occur, there is commonly still so much resistance at the pylorus, and more especially at the valve of the colon, as to turn the direction again into its proper course. In the colon, from its position, structure and the consistence of its contents, the progress of these is more slow and difficult ; and it is therefore here assisted by the longitudinal fibres peculiarly disposed, so as by their contraction to contribute more to the dilatation of every succeeding portion of the intestine.

CCXXVI.

The chyle is taken into the lacteals, and moved onwards in these in the same manner (CLXVII.) as the lymph is in the several lymphatics in other parts of the body, to which the lacteals are in structure and situation exactly similar.

CCXXVII.

The course of the alimentary matters, and the motions by which they are carried on, being now explained, we return to consider the several changes which the aliment undergoes in this course.

CCXXVIII.

In the mouth, if the aliment taken in be of a solid consistence, it is here, as we have said, subjected

jected to a triture ; and if our food is of a soft and moist kind, we are instinctively directed to take in along with it some dry matter, as bread, that the whole may be subjected more certainly to a complete manducation. By this our aliment is not only more minutely broken down, but is also intimately mixed, with the liquids at the same time taken in, with the saliva and other fluids of the mouth, and with a quantity of air intangled by these viscid fluids.

CCXXIX.

In this divided and moistened state, the aliment is taken down into the stomach, where it is farther dissolved, the vegetable matter of it begins to be changed to the nature of animal, and the oily parts of the whole begin to be united with the watery. But these changes by solution, assimilation, and mixture, require to be separately considered.

CCXXX.

The solution here, as in other cases, may be assisted by the mechanical division of the solid matter, by the agitation of the dissolving mass, and by the application of heat ; and, with these assistances, the solution must be performed by the application of a proper menstruum.

CCXXXI.

The division of the solid is sometimes assisted by a previous cookery, and commonly by the manducation we have mentioned ; but the human stomach does not seem by any mechanical powers to contribute to this. It gives only a moderate agitation,

agitation, which, in any case, contributes little to mechanical division.

CCXXXII.

The degree of heat applied here, being that of the common temperature of the human body, may assist the solution ; but it is of no considerable power, and no assistance is got from any closeness of the vessel which occurs here Upon the whole, the assistances applied here are not considerable, and the speedy solution that takes place must be chiefly owing to the power of the menstruum.

CCXXXIII.

The menstruum that appears here, is a compound of the liquid matters taken in, of the saliva, and of the gastric liquors : but in all, or any of these, we do not readily perceive any considerable solvent power ; nor, by any artifice, in employing these out of the body, can we imitate the solutions performed in the stomach.

CCXXXIV.

However, from what happens in the stomachs of certain animals, there is ground to presume, that indeed in every one there is a peculiar solvent. But whether this be a menstruum dividing the solid into integrant parts, and thereby reducing it to a fluid state, or if the solvent here be a peculiar fermentative power, resolving matters more or less into constituent parts, is not clearly perceived.

CCXXXV.

The latter is the most probable, as the circumstances

stances of fermentation very constantly appear ; and as the deviations which at any time appear in the course of digestion, appear always to be an excess of fermentation, either acescent or putrefactive.

CCXXXVI.

The business seems to us to proceed in this manner. The fluids of the stomach have the power of suddenly and powerfully loosening the fixed air of the alimentary matters, which is the first step towards putrefaction, and that which most effectually breakes down the texture, and perhaps the mixture of bodies. But we now know, that putrescent bodies are very powerful in exciting an acescent fermentation in vegetable substances, which the human stomach is hardly ever without ; and that this acescency therefore, in the next place, very constantly succeeds, and an acid is produced in the stomach. This acidity makes the effects of the putrefaction disappear ; and the acidity in its turn disappears also, probably by its being absorbed by, or united with, the putrescent and oily matters here present ; and it is in this manner that we suppose that the animal fluid is produced, and daily renewed by the combination of a fresh portion of acid with putrescent fluids previously existing in the body. The daily production of acid in the human stomach, and its readily disappearing again, without showing any morbid effects, renders our doctrine sufficiently probable.

CCXXXVII.

This is the assimilation of vegetables that I
suppose

suppose to take place, and is begun in the stomach but is not completed there : for we observe, that the long retention of the alimentary matters in the stomach, whether from the insolubility of the matter, or from an obstruction of the pylorus, produces a greater degree of acidity : and in general, the acidity which commonly prevails in the stomach does not disappear but in the after course of the aliment.

CCXXXVIII.

It is especially the bile, added to the matters which have passed from the stomach into the duodenum, that is fitted to cover the acidity which appeared in the stomach. It is probable also, that the pancreatic and intestinal liquors contribute to the same effect ; and it is perhaps for the same purpose, that the lymph is constantly added to the chyle in its course. But, after all, we must rest in the general idea, and own that we do not know exactly how this matter proceeds, nor what the several fluids, added to the aliment in different parts of its course, truly contribute to the changes of it.

CCXXXIX.

It is probable, however, that, by the mixture mentioned, the peculiar fluid which we name the *chyle* is produced ; for, though it is certain that a variety of fluid matters may enter the lacteals and accompany the chyle there, it is still probable, that there is a peculiar fluid produced by the actions of the stomach and intestines, and such as becomes the principal ingredient in the animal fluids

fluids afterwards formed, that is strictly intitled to that appellation. This chyle does not appear in the stomach ; but first in the duodenum, and more copiously still in the jejunum and first part of of the ileum. It appears indeed in the whole of the ileum, cœcum, and colon, but in the last less copiously ; all which shows that a particular mixture is necessary to it ; and at the same time that it is not made at once, but successively in the course of the intestines.

CCXL.

It remains to speak of the mixture of the oily with the watery parts of the aliment. This we cannot well explain ; but it is of consequence to observe here, that such a mixture is actually made. It is evident that a large quantity of oil in a separate state is taken in as a part of our aliment, but at the same time no oil commonly appears in a separate state in the mass of blood ; it must therefore be united with the other parts of the mass in the way of mixture. Hitherto the physiologists have hardly mentioned any other means for this union of oil but the application of viscid fluids ; but these can occasion only a diffusion, and some means of mixture must necessarily be supposed. What these however are, we do not certainly know. They do not produce their effect in the first passages ; for in the chyle till it enters the subclavian vein, the oil appears to be only in a diffused state, and probably the perfect mixture is only made in the passage through the lungs.

CCXLI.

It may be proper here to take notice of another
matter

matter which constantly enters into the mixture of animal fluids. This is air, which, by different means can be extracted in considerable quantity from every kind of animal matter. What is properly the origin of this, when and where it is insinuated into the animal fluids, and by what means it is either fixed in these or loosened from them, are all questions not yet resolved ; but perhaps necessary to be resolved, before we can speak with any confidence of the changes which the animal fluids undergo in different parts of the system. We can observe, in the mean time, that a quantity of air is always present in the chyle in a very loose state ; that it becomes more fixed in the mass of blood after this has passed through the lungs ; and that again, in the different secreted fluids, the air appears to be in some of them still fixed, and in others much more loose ; and it is probable, that all this has a particular relation to the production and properties of the different fluids of animals.

CCXLII.

We have now followed the course of the aliments, so far as we can consider them as any ways in a separate state ; but we do not perceive, that, in any part of this course, the proper animal fluids are entirely formed : And it is very justly supposed, that the proper mixture or assimilation is not finished till the chyle, mixed with the mass of blood, has undergone the action of the lungs, through the vessels of which it must almost immediately pass, after entering the subclavian vein,

and seemingly before it is applied to any of the purposes of the animal œconomy.

CCXLIII.

What change the fluids undergo in passing through the lungs, or by what means the supposed changes are produced, after all has been said, seems still to be very little known.

The mechanical powers of pressure, commonly spoken of, do not in fact take place, nor are their supposed effects any ways consistent with sound philosophy; and, on the other hand, it is very probable, that the changes produced are the effects either of chemical separation or mixture.

What has been supposed to be performed in this way by an absorption of air, or of a particular matter from it, is very uncertain in fact, and has led to a still more uncertain reasoning.

It is now certain, that a quantity of mephitic air, and perhaps some other matters are constantly exhaling from the lungs of living animals, and are carried off by the atmospherical air alternately entering and issuing from the lungs. This is a pretty certain evidence that some change of mixture is going on in the fluids passing through the lungs; but from what particular portion of the fluids the mephitic air proceeds, or what is the effect of its separation, we know not: And indeed, as we have said before, what are the effects of the action of the lungs upon the state of the fluids, we are uncertain. Upon the whole, we still know but little of the production, or formation, of the animal fluids; and therefore from the consideration

ration of their formation, we have learned little of their nature ; but we must now try to discover what we can of it, by examining these fluids as they are found already formed in the blood-vessels.

S E C T. IV.

C H A P. II.

O F A N I M A L B L O O D.

CCXLIV.

THE red fluid passing from the lungs to the left ventricle of the heart, and thence by the aorta and its branches to every part of the body, may be considered as a mass containing, either formally or materially, every part of the animal fluids ; and may therefore be called the *common mass of blood*. This term, however, must be strictly confined to the circulating fluids while they retain their red colour ; for when they loose this, it is always in consequence of some separation of parts. The same red fluid, indeed, as it is found in the veins, has also suffered some separation of parts ; but as the blood in the veins is never entirely deprived of the whole of any matter that was present in the arteries, so we think the venous blood may still be considered as a part of the common mass.

CCXLV.

This mass of blood we find to be an heterogeneous aggregate ; and it will be proper to inquire
into

into the several parts of this before we employ any chemical trials for discovering the mixture of the whole, or of its parts.

CCXLVI.

We discover the parts of this aggregate chiefly by the spontaneous separation of them, which takes place upon their being drawn out of the vessels of a living animal.

CCXLVII.

The separation commonly proceeds in this manner. Immediately after the blood is drawn out, it exhales a sensible vapour, and after some time, it is found by that exhalation to have lost a part of its weight, more or less, according to the degree of heat it is exposed to, according to the extent of surface by which it is exposed to the air, and probably also according to different conditions of the blood itself. The matter thus exhaling may be called the *halitus* or vapour of the blood.

CCXLVIII.

Soon after the blood has been drawn out of the vessels, it loses its fluidity, and the whole of it concretes into one soft gelatinous mass: but after some time, there oozes out from this mass a thin fluid; and as the separation of this proceeds, the mass contracts into a smaller bulk, and, in proportion, becomes more dense.

CCXLIX.

This is the separation which almost always takes place, and has at all times been observed by physicians. The fluid part is called *serum*; and

and the thicker consistent part has been called *cruor*, but more properly the *crassamentum*.

CCL.

Both parts seem homogeneous and simple, but are not. For, if the *crassamentum* taken from the serum be laid upon a linnen cloth, and water is poured upon it, the water washes off a red coloured part, and carries it through the pores of the cloth; and there remains a whitish, consistent, but soft and tough mass, not to be further diminished or separated into parts by any ablution.

A like experiment shows always a like matter present in the mass of blood; and upon several occasions, both while the blood remains within the vessels, whether of the living or dead body, and when it is drawn out of the vessels of the living, this matter spontaneously separates from the other parts of the blood. It is therefore a part constantly present in the blood. It is what Gaubius, after Malpighi, calls the *fibra sanguinis*. Mr Senac names it the *coagulable lymph*; and we shall speak of it under the title of the *gluten of the blood*. When it appears upon the surface of the blood drawn out of the vessels of the living animals, it is called the *inflammatory crust*.

CCLI.

When the blood is viewed with a microscope, whether as moving in the vessels of a living animal, or when out of the vessels remaining still fluid, there are certain parts of it which appear of a round figure, and also of a red colour, while the rest is almost colourless. The parts thus distinguishable

guishable by their figure are called the red globules ; and it appears that the red colour of the whole mass depends upon the presence of these only. It is chiefly these parts which are washed off from the crassamentum in the experiment above mentioned ; and we now conclude, that, besides the globules, the gluten, and a portion of serum that happens to be entangled in the pores of the concreting mass, there is no other matter evident in the crassamentum.

CCLII.

The serum is a transparent fluid of every little colour, and seemingly simple ; but if it be exposed to a heat of 156 degrees of Fahrenheit's thermometer, it concretes into a firm and almost transparent jelly ; and, if this be cut in minute pieces, there exudes from it a thin colourless fluid of a saline taste. In proportion as this fluid is more carefully separated, the coagulated part becomes insipid, and in all its properties resembles the gluten separated from the crassamentum. From hence we are ready to conclude, that the serum, as obtained by spontaneous separation, consists of a portion of gluten dissolved in a saline fluid, which we name the SEROSITY.

CCLIII.

From the whole that has been said from (CCXLIV. to CCLII.) it appears that there are three distinct portions and kinds of matter in the common mass of blood ; that is red globules, gluten, and serosity. What other matters may also be there, we shall consider afterwards ; but, in the
mean

mean time, shall say a little more of each of the parts we have already mentioned.

CCLIV.

The red globules have been considered as an oily matter, and from thence their distinct and globular appearance has been accounted for ; but there is no direct proof of their oily nature, and their ready union with and diffusibility in water renders it very improbable. As being microscopical objects only, they have been represented by different persons very differently. Some have thought them spherical bodies, but divisible into six parts, each of which in their separate state were also spherical ; but other persons have not observed them to be thus divisible. To many observers, they have appeared as perfectly spherical, while others judge them to be oblate spheroids or lenticular. To some they have appeared as annular ; and, to others, as containing a hollow vesicle. All this, with several other circumstances relating to them, very variously represented, show some uncertainty in microscopical observations ; and it leaves me, who am not conversant in such observations, altogether uncertain with respect to the precise nature of this part of the blood. The chemical history of it is equally precarious ; and therefore, what has been hitherto said of the production, and changes happening to these red globules, we choose to leave untouched. We shall afterwards say something with respect to their general use in the animal system ; and now we shall attempt to explain the cause of some changes, which in certain circumstances

stances appear in the colour of the whole mass of blood.

CCLV.

We suppose that the red globules, when viewed singly, have very little colour ; and that it is only when a certain number of them are laid upon one another, that the colour appears of a bright red : but this also hath its limits ; so that, when the number of globules laid on one another is considerable, the colour becomes of a darker red. Upon this supposition, the colour of the mass of blood will be brighter or darker as the colouring part is more or less diffused among the other parts of the mass ; and we think this appears to be truly the case, from every circumstance that attends the changes which have been at any time observed in the colour of the blood.

CCLVI.

The gluten of the blood, from its resemblance on the one hand to the *albumen ovi*, and on the other to the matter of the solids of animal bodies, we consider as the principal part of animal fluids, as that which is immediately formed of the aliment taken in, and as that which is employed in increasing the growth of the solids, or in repairing their waste.

CCLVII.

But it is well known, that the animal fluids in general, and particularly the gluten, is prone to putrefaction ; and that even in the living body, if fresh aliment be not constantly taken in, and also if certain excretions which carry of putrescent
matter

matter be not constantly supported, a considerable putrefaction certainly takes place. From hence we are led to think, that some approach to putrefaction constantly takes place, even in the most healthy bodies ; and that it appears especially in an evolution of saline matter ; and that this, taken up by the water constantly present, forms the serosity. We suppose it is this which affords the vapour of the blood, (CCXLVII.) and that it is the serosity dissolving a portion of the gluten which forms the serum that appears upon spontaneous separation (CCXLVII.)

CCLVIII.

The saline matters impregnating the serosity, if we may judge from the analysis of urine, are of various kinds ; but particularly, there is present an ammoniacal salt, now well known under the name of the *essential salt of urine*, which, if not originally formed, is at least most copiously evolved in animal fluids.

CCLIX.

These are our conjectures concerning the parts of animal blood ; and it remains to say in what proportion each of them is present in it. This will perhaps be always difficult ; and in the meantime we can perceive, that many estimates formerly made could not be exact, as the several parts were not properly known ; and while judging chiefly from the appearances upon spontaneous separation, physicians were not aware how much these are affected by the circumstances of extravasation, and by those in which the blood is placed

after being drawn out. There are not yet indeed experiments made to ascertain, with any exactness, the proportion of the several parts mentioned : but it is probable, that the red globules make a small part of the whole ; that the gluten, if we consider both what is in the crassamentum and in the serum, is in much larger proportion ; but that the watery portion is the largest of all, and at the same time that this has always a considerable quantity of saline matter dissolved in it.

CCLX.

We would next put the question, By what means the parts of this heterogeneous mass are kept so equably diffused among one another, and the fluidity of the whole so constantly preserved ? This we suppose to be done chiefly by motion and heat, and by the parts disposed to concreté being kept from the contact of any matters to which they might adhere more firmly than they do to the other parts of the blood. The diffused parts we suppose to be present only in those vessels in which a considerable degree of agitation is constantly kept up ; and we suppose also, that the heat always here present, both diminishes the cohesion of the gluten, and increases the solvent power of the serosity. Experiments made with neutral salts seem to confirm the latter ; and it is also probable, that the same solvent power may be increased by a quantity of air that is constantly intermixed with the mass of blood while it remains in the vessels, and is under a constant agitation. It is supposed, that an attention to these several circumstances will explain
 most

most of the cases of spontaneous separation that occur either in the living or dead body, within the vessels or without them ; but the detail would be too long for this place.

CCLXI.

We shall add here a few words on the use of this singular composition of animal blood which we have been considering.

It appears evidently, from many circumstances of the animal œconomy, that its functions require a system of vessels constantly filled, and even distended ; but as, at the same time, these vessels must be open by a multitude of their extremities, if all the fluids were such as could pass by these extremities, the system could not be kept filled for a few minutes. It is necessary, therefore, that the fluids should be partly of such a size as that they cannot pass through the smaller vessels, and partly in a diffused state only, which has commonly the same effect. Hence it is, that the red globules, under the ordinary impetus of the heart and arteries, are strictly confined to certain vessels ; and it is probable, that, in the like circumstances the diffused gluten does not go much farther. This serves to keep the larger vessels of the system constantly filled. But, on the other hand, the serosity being sufficiently fluid, might be supposed to run off by the many outlets open to it, and thereby to leave the fluids in the larger vessels of a consistence unfit to circulate. This, however, seems also to be obviated by the viscosity of the grosser parts of the blood, sufficient always to entangle so much
of

of the more fluid, as may be necessary to preserve the due fluidity of the whole.

CCLXII.

The heat of the human body, supported by powers within itself, is probably the effect of the motion of the blood, and might have been treated of when we were considering that subject. But as many persons suppose it to depend in some measure on the nature of the fluids, we have reserved it for this place ; and here perhaps to say only, that the question concerning the cause of animal heat is not yet solved.

CCLXIII.

The opinion of animal-heat's being the effect of mixture, is to be little regarded ; as the matters supposed to be mixed, the place in which the mixture is made, and the other circumstances relating to it, are equally hypothetical, and the whole is ill supported by any analogy.

CCLXIV.

More speciously is animal-heat supposed to be the effect of putrefaction, towards which there is certainly some approach in animal bodies ; but the opinion is still very doubtful. For, *first* the effect of any degree of putrefaction in producing heat is not well ascertained. *Secondly*, It is not supported by any analogy, that putrefaction, in the degree to which only it proceeds in living bodies, is capable of producing the heat appearing there. And *lastly*, Whatever is the degree to which putrefaction proceeds in living bodies, it
does

does not appear that there is any increase of heat correspondent to the increase of putrefaction, and rather the contrary.

CCLXV.

The suppositions either of mixture or of putrefaction, as the cause of animal-heat, are both of them rejected by this, that the generation of heat in animal bodies is manifestly dependent on another cause, that is, the motion of the blood. For the power of generating heat in any animal is not perfect till the motion of the blood in it is fully established; and, when the generating power is established, we perceive the heat to be increased or diminished as various causes increase or diminish the motion of the blood. In dying animals, the heat grows less as the motion of the blood grows less; and when at death this ceases altogether, the heat ceases also, commonly, at least, as soon after death as we can suppose a body of the same bulk to loose the heat it had acquired.

CCLXVI.

This connection between the heat and motion of the blood seems in general to be well proved; and, though it may be difficult to reconcile certain appearances to it, we would so far admit of the supposition, as to inquire, in the next place, into the manner in which the motion of the blood may generate heat.

CCXLVII.

On this subject, the most common opinion is, that the heat is produced by the attrition of
the

the particles of the blood upon one another, or of these on the internal surface of the vessels in which they move. But we cannot find any analogy to support either the one or the other supposition.

The attempt made to support the latter supposition, by endeavouring to show, that upon this the equality of heat in the different parts of the same body is well explained, deserves little regard, as it is founded on doubtful principles and mistaken facts.

CCLXVIII.

The equality of heat in the different parts of the same body seems to require the generating power to be very generally diffused over the whole ; but it does not seem to require its being precisely equal in every part, as the interposition of pretty large vessels in every part of the body, and the speedy communication of the fluids from any one part to every other, will sufficiently account for the equality of heat, though the generating power should be in some measure confined to certain parts only.

However, we take no notice of the suppositions which have been made of the generating powers being confined to certain small portions of the system only. These suppositions give no relief in the general theory, and they are not supported by any particular evidence. The breathing animals are the warmest ; but that they are warmer because they breathe, is not more probable than that they breathe because they are warmer.

CCLXIX.

CCXLIX.

With respect to this theory, which deduces animal heat from the motion of the blood, we must own, that it is attended with several difficulties. It will be difficult to show, in so many animals of different age, size, and temperament, in which the degree of heat is nearly the same, that the motion of the blood, in all its circumstances, is also exactly the same ; or to show, in the different animals in which the degree of heat is considerably different, that the motion of the blood in each is correspondent to the difference of heat. May it not be supposed, that there is some circumstance in the vital principle of animals which is in common to those of the same class, and of like œconomy, and which determines the effect of motion upon the vital principle to be the same, though the motion acting upon it may be in different circumstances ?

CCLXX.

In all we have hitherto said of animal fluids, we have considered the common mass of blood as consisting of three parts or three kinds of matter only ; but many more have been supposed to be present in it, and we shall inquire upon what ground.

It is common to suppose, that the aliment or the chyle formed of it is not perfectly assimilated in passing once only thro' the lungs ; but that for some time after such passage, it continues to circulate with the blood under the same form and of the same qualities which it had when it first entered the subclavian, and particularly in this
state

state to furnish the milk which is secreted in the breasts of females. There is, however no proper evidence of the chyle's ever appearing in the blood-vessels, and the appearances of it alledged can be otherwise accounted for. The arguments for the same opinion, which are drawn from the consideration of the secretion of milk, are embarrassed with many difficulties.

CCLXXI.

It is probable, that the animal fluid (CCLV. CCLVI.) is in a constant progress, and hardly for a moment stationary, or therefore uniformly the same over the whole of the common mass. Some part of it is that which was last formed, and therefore the nearest to the vegetable matter from which chiefly it was produced; while another part of it is that which has remained longest in the body, and is therefore the nearest to putrefaction. Between these two there may be several intermediate states, which, however, like the nearest shades of the same colour, are not distinguishable by our senses or experiments.

CCLXXII.

Besides the difference of matter arising from the progress of the animal fluid, there have been other matters supposed present in the common mass, and as commonly constituent parts of it. Such are a mucous matter, like to the mucous matter of vegetables; and a gelatinous matter, like to that which is extracted by decoction from the solid parts of animals. But there is no evidence of either being formally present in the mass of
blood,

blood, and the supposition is founded on mistaken facts and false reasonings

CCLXXIII.

But it is proper to be observed here, that many extraneous matters may, by different ways, be introduced into the blood-vessels ; and that many of the secreted fluids, sometimes very different from any thing that existed before in the mass of blood may, by absorption or regurgitation, be again taken into the blood -vessels : But, with regard to all of these, whether extraneous matters, or those produced in the body itself, it is probable that hardly any of them enter into the mixture of the animal fluid, and that they are only diffused in the serosity till they can be again thrown out of the blood vessels by the readiest outlets. The oil of the adipose membrane is frequently, and perhaps necessarily reabsorbed, and seems to be, besides the lymph, the only reabsorbed matter which enters again into the mixture of the animal fluid.

S E C T. IV.

C H A P. III.

O F S E C R E T I O N.

CCLXXV.

AFTER thus considering the parts of the mass contained in the red vessels, we must next consider the several fluids which appear in the other parts of the body.

CCLXXVI.

All of these we suppose to be derived from the common mass, as they appear in vessels continuous with those of the common mass, and as their appearance ceases when the communication of the vessels containing them, with the sanguiferous vessels, is any how interrupted.

CCLXXVII.

The fluids thus derived from the common mass seem to be produced in consequence of a certain structure, with perhaps some other condition in the extreme vessels through which the fluids pass; and a part having such a structure, is called a *gland* or *secretory organ*, the function of which, from the most obvious notion of the manner of it, is called *secretion*.

CCLXXVIII.

The structure of the organ, and the manner of its function, seem to me for the most part unknown; at least, what we know or suppose with regard to the structure hardly in any case applies to the explanation of the function.

CCLXXIX.

If it any how appeared that the several secreted fluids were all of them previously existent in the same forms in the mass of blood, it would not perhaps be difficult to explain what might be strictly called a secretion. But such previous existence does not appear; for, except the matter of exhalation into the several cavities of the body, and the matter of urine and of perspiration, we
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find no proper evidence of any other secreted fluids present in the mass of blood. We cannot find there, either milk, mucus, or oil, and much less the appearance of many other fluids which are only found after they have passed through certain organs.

CCLXXX.

This being the case, the considerations of the physiologists with regard to the velocity of the blood, and other circumstances favouring the separation of the parts of a fluid which are only diffused among one another, deserve no attention. The effects of different apertures may go some length ; but we can perceive their particular application only in the few cases of a simple separation. In most others, there appears to be a change of mixture ; but we perceive neither the precise changes that are made , nor the cause of them.

CCLXXXI.

Till we can discover these more clearly, we may in the mean time observe, that the action of the vessels of the secretory organ has a considerable share in determining both the quantity and quality of the secreted fluid, and that both very often are very little affected by the general state of the circulation, or by the different conditions of the mass of blood.

CCLXXXII.

It would seem that no other secretion but those of perspiration and sweat are manifestly increased by the increased action of the heart and arteries
(CLXXXI.),

(CLXXXI), and that most of the other secretions are increased only by stimulants applied to their organs. These stimulants may be either such as are immediately applied externally or internally to the excretory, or perhaps to the secretory vessels; or they may be such as are applied to the sensorium, or to distant parts of the nervous system, which by the laws of the animal œconomy have a connection with the organs of secretion. These stimulants, at the same time that they act in either of these ways on the secretory organs, for the most part have no sensible effect on the general state of the circulation of the blood.

CCLXXXIII.

With respect to the influence of the condition of the common mass of blood upon the several secretions, we presume that the state of the quantity of the fluids in general will affect the quantity of every secretion; but the effects of the quantity of the whole mass are very remarkable only, with respect to the secretions of perspiration, urine, and milk.

The qualities of the common mass may also be presumed to affect the several secretions: but the effect of these qualities appears most remarkable in the same secretions of perspiration, urine, and milk; and, even in these, the effect seems to depend upon the proportion of water more than upon that of any other matter in the common mass. With respect to the other secretions, we cannot perceive that any of them are increased by a particular matter present in the mass of blood, except

cept it be such a matter as stimulates the secretory organ.

CCLXXXIV.

The several secretions are frequently observed to affect each other mutually, so that the increase of one diminishes another, and *vice versa*. This seems to depend either upon a change of determination in the course of the blood (CLXXVIII.), or upon a change in the state of fluidity of the common mass, or perhaps upon a connection established between the different organs of secretion as parts of the nervous system; and, except it be in the case of perspiration and urine, we cannot perceive that the effect of the state of one secretion upon that of another depends upon an increase or diminution of any particular matter in the mass of blood.

CCLXXXV.

After mentioning these generalities with respect to secretion, we should, perhaps, proceed in the next place to consider the application of them to the particular secretions, and also to consider more particularly the several secreted fluids; but we omit both these subjects, as we presume the former will be obvious from what is already said; and with respect to the latter, we have not yet a sufficient number of experiments to proceed any length in it.

S E C T. IV.

C H A P. IV.

O F N U T R I T I O N.

CCLXXXVI.

UNDER this title we might consider how the matter both of the fluids and solids of the body is supplied : but, after what we have formerly said of the taking in and assimilation of the aliment, we have nothing now to add with respect to the fluids ; and we therefore confine ourselves here to consider in what manner the solid parts obtain their increase of matter and growth, or have their occasional waste repaired.

CCLXXXVII.

There is no doubt that the solids are formed of the fluid prepared from the aliment in the manner we have said ; but it is required now to say what portion of the fluids is employed in nourishing the solids, by what channels the nourishment is conveyed to them, and, being applied there, how from fluid it becomes solid.

CCLXXXVIII.

With regard to the first question, we have no doubt in asserting, that in oviparous animals, it is the albumen ovi that is employed in nourishing the chick ; and we presume that it is an analogous fluid which is employed in nourishing the bird during the the whole time of its growth. We think
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the analogy may be safely applied with respect to all animals, the solid matter of which is of the same kind with that of the oviparous.

CCLXXXIX.

This analogous fluid we take to be the gluten of the blood, properly diluted and freed from any adhering saline matter.

CCXC.

To determine in what manner this nutritious fluid is applied to the nourishment of the solids, it is necessary to consider what are the simple fundamental solids, of which all the others are formed.

CCXCI.

It seems to be the opinion of the greater part of modern anatomists, that the solid parts consist entirely of a cellular texture, of various density in the different parts ; and indeed, the structure of the greatest part of the solids is evidently of this kind. But at the same time, it is also true, that a fibrous structure is to be observed almost every where in the body. It appears in the medullary substance of the brain and nerves, in the muscles and tendons, in the arteries, in the excretories of the glands, in the lymphatic vessels, in the alimentary canal, in the uterus and bladder of urine, in the ligaments, in most membranes ; and it is to be seen in those membranes which are afterwards changed into bones, especially whilst this change is going on.

CCXCII.

From this view of the universality of a fibrous structure in animal bodies we are disposed to believe,

lieve, that these fibres are the fundamental part of animal solids ; that they are the primordial staminal part of animal bodies ; and that the cellular texture is, for the most part, an accretion formed upon these fibres.

The consideration of the structure and growth of vegetables seems to illustrate and confirm this opinion.

CCXCIII.

At the same time, from the fibrous parts (CC-XCI.) being evidently, in most instances, parts of the nervous system, and from the gradual formation of the fœtus in which the nervous system is first formed. we think it probable, that the whole of the fibres in the different parts of the body are a continuation of the nerves ; and this again will lead to the conclusion, that the nourishment of the soft and homogeneous solid every where is conveyed to it by the nerves.

CCXCIV.

This supposes also, what is otherwise probable, that the cortical part of the brain, or common origin of the nerves, is a secretory organ, in which the gluten of the blood being freed from all saline matter before adhering to it, becomes fit for the nourishment of the solids, and being poured in a sufficiently diluted state upon the organ of the nerves, it is filtrated along the fibres of these, and is thus conveyed to every staminal fibre of the system. We suppose, at the same time, that the medullary, or what may be called the solid matter of the nerves, is in the living body constantly
accompanied

accompanied with a subtle elastic fluid, which fits them for being the organs of sense and motion, and which probably is also the means by which the nutritious fluid is carried on in the substance of the nerves, from their origin to their extremities.

In what manner the nutritious fluid, thus carried to the several parts, is there applied, so as to increase the length of the nervous fibre itself, or form a cellular texture upon its surface, and in what manner from fluid it becomes solid, we cannot explain; nor can these particulars be explained upon any other supposition that has been formed with respect to nutrition.

CCXCV.

It is probable, that, for a certain time, at its first beginning, the growth of animal bodies proceeds in the same manner as that of vegetables: but it is evident, that, at a certain period, in the growth of animals, a different œconomy takes place; and that, afterwards, the growth seems to depend upon an extension of the arteries in length and wideness by the blood propelled into them by the powers (CLVI. CLIX.) It may be supposed, that this extension of the arteries is applied to every fibre of the body, and that by the extension of these it gives an opportunity to the application and accretion of nutritious matter; to the growth therefore of the fibre itself, and to the growth of cellular texture on its surface. Perhaps the same extension of the arterial system gives occasion to the secretion of fluids, which poured into the cellular texture already formed, according to the dis-

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position of these fluids to concrete more or less firmly, gives the different degrees of density and hardness which appears in different parts of the body.

CCXCVI.

By this extension of the arterial system, the several parts of the body are gradually evolved, some of them sooner, others later, as by the constitution of the original stamina, or after occurrences, they are severally put into the conditions (CLXXVII. CLXXVIII.) by which they are more or less exposed to the impetus of the blood, and fitted to receive a greater quantity of it. But as the parts by these causes first evolved will increase the most in the density of their solid parts, they will therefore more and more resist their further growth; and by the same resistance, will determine the blood with more force, and in greater quantity, into the parts not then so far evolved. Hence the whole system will be at length evolved, and every part of the solids will, in respect of density and resistance, be in ballance with every other, and with the forces to which they are severally exposed.

CCXCVII.

The extension of the arteries (CCXCV.) depends upon the resistances which accrue to the free transmission of the blood through them, as in (CLXX.) ; and further, from a resistance in the veins. For as a considerable portion of the blood (by CCLXI.) does not commonly pass into the smaller branches of the arteries, but must pass very entirely into the veins ; so these, by their capacity

ty constantly diminishing as they approach nearer to the heart, and by their coats being of a density and firmness sufficient to prevent further dilatation, considerably resist the free passage of the blood from the arteries into them.

CCXCVIII.

While these resistances continue, the arteries, and with them almost every fibre of the body, must be extended at every systole of the heart; and with this extension, the growth of every part will proceed: but, as every part, by its receiving an addition of solid matter, becomes more dense and rigid; so it is less easily extended, and perhaps less readily receives an accretion of new matter, than before. Hence it is, that the more the body grows, it admits of any additional growth more slowly; and unless the extending powers increase in the same proportion with the increasing density of the solids, there must be a period at which these two powers will balance each other, and the growth will proceed no farther. But, as it is evident, that the bulk and weight of the heart and probably therefore its force, does not increase with the increasing bulk of the body, and that the action of the heart is the principal extending power in the system; it is also plain, that the extending power does not increase in the same proportion with the increasing density of the solids; and therefore, that these two powers will, at a certain period come to balance each other.

CCXCIX.

But not only is the force of the heart thus con-

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stantly diminishing, with respect to the resistance of the arteries ; but the force of the heart, though it were still subsisting, has, from other causes, less effect in extending the arteries. The blood is more confined to the arteries, and extends them further in proportion to the resistance in the veins, as in (CCXCVII.) ; and this resistance in the veins, and the extension of the arteries depending upon it, will be more or less, according to the respective density of these two sets of vessels. But it appears from the experiments of Sir Clifton Wintringham that the density and firmness of the veins with respect to their correspondent arteries, is much greater in young animals than in old ; and thence it appears, that during the growth of animals, the arteries are acquiring an increase of density in a greater proportion than the veins are at the same time ; and therefore, that the resistance in the veins with respect to the arteries, must be constantly diminishing ; that the veins will therefore receive a greater proportion of blood ; that in the same proportion the arteries will be less extended ; and, *lastly*, that the diminished resistance in the veins, concurring with the diminished force of the heart, will the sooner bring the increasing rigidity of the arteries, and therefore of every fibre of the body, to be in balance with the extending powers ; at least, so far as to prevent their producing any further growth.

CCC.

This account of the change of the resistances in the arteries and veins. with respect to one another,
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is agreeable to phenomena, which show that the arteries are larger, and contain more blood in proportion to the veins in young animals, than in old ; that arterial hemorrhagies occur most frequently in young persons ; and that congestions in the veins, with hemorrhagies, or hydropic effusions depending upon them, occur most frequently in old age.

CCCI.

It is probable, that the resistance both of arteries and veins goes on increasing, while the force of the heart is not increasing at the same time ; but it appears also, that, from the diminished force of the heart, and the compression which the smaller vessels are constantly exposed to from the distention of the larger, the action of the muscles and other causes, the number of small vessels, and therefore the capacity of the whole system, is constantly diminishing so much, that the heart may still for some time be sufficient for the circulation of the blood. But, while the resistances in the vessels are constantly increasing, the irritability of the moving fibres, and the energy of the brain, are at the same time constantly diminishing ; and therefore the power of the heart must at length become unequal to its task, the circulation must cease, and death ensue.

CCCII.

The unavoidable death of old persons is thus in part accounted for ; but it is however, still probable, that the same event proceeds chiefly from the decay and total extinction of the excitement
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or vital power (CXXXVI.) of the nervous system, and that from causes very independent of the circulation of the blood, and arising in the nervous system itself in consequence of the progress of life. This seems to be proved by the decay of sense, memory, intellect, and irritability, which constantly takes place, as life advances beyond a certain period.

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